Operator
& Service Manual

NSN 6515-01-287-0607

A.T.S.® 1500
TOURNIQUET SYSTEM

zimmer

LIMITED ONE YEAR WARRANTY

SCOPE OF WARRANTY

Zimmer, Inc. warrants the Product (*A.T.S.* 1500 Tourniquet System) for one year from date of purchase. During the warranty period Zimmer will repair or replace, at its option, any Product which is defective in materials or workmanship or which fails to meet the published product specification for that model. This Limited Warranty is made only to the original purchaser of the Product and is non-transferable. The remedies described in this Limited Warranty are the exclusive remedies for breach of warranty. **THIS WARRANTY SHALL NOT APPLY TO ANY PRODUCT WHICH HAS BEEN ALTERED OR MODIFIED IN ANY WAY OR WHICH HAS BEEN SUBJECTED TO MISUSE OR ABUSE.**

DISCLAIMER OF IMPLIED WARRANTIES

The foregoing Express Limited Warranty is given in lieu of any and all other express or implied warranties. ZIMMER MAKES NO OTHER WARRANTIES INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

LIMITATION OF REMEDIES

In no case shall Zimmer, Inc. be liable for any special, incidental or consequential damages whether based on breach of warranty or other legal theory. Some states do not allow limitations on warranties or on remedies for breach in certain transactions. In such states, the limits in this paragraph and the preceding paragraph do not apply.

WARRANTY CLAIMS

In the event of a warranty claim within the warranty period please take the following steps:

1. Notify Customer Service Department, Zimmer Patient Care Division, Dover, Ohio at 1-800-321-5533 or contact your local Zimmer representative. Please provide details about the nature of the problem and include the Product serial number. Upon receipt of this information Zimmer will provide you with a date for service or a return shipping authorization.

2. Upon receipt of the shipping authorization, forward the equipment, freight prepaid, to the location specified in the shipping authorization.

Your compliance with these steps will help assure that you receive prompt warranty service for your Product.

The revision level of this manual is completely specified by the Rev. letter printed on this page and by any errata that follow.

Zimmer Patient Care Division©
P.O. Box 10, 200 West Ohio Avenue, Dover, OH 44622
Phone: (330) 343-8801 / 1-800-321-5533

Manual Number 60-4019-002

Unit Serial Number____________

TABLE OF CONTENTS
& LIST OF ILLUSTRATIONS

A.T.S. 1500 TOURNIQUET SYSTEM

SECTION	TITLE	PAGE
1.0	GENERAL INFORMATION	3
1.1	Features	3
1.2	Specifications	4
1.3	Intended Use	5
1.4	Contraindications	5
1.5	Precautions in Use	5
1.6	Adverse Effects	6
2.0	INSTALLATION AND OPERATING INSTRUCTIONS	7
2.1	Initial Inspection	7
2.2	Functional and Calibration Check	7
2.3	Installation	9
2.4	Controls, Indicators and Connectors	9
2.5	Single Cuff Operation	11
2.6	Dual Cuff Operation	12
2.7	Bier Block Operation	14
2.8	Alarm Conditions	14
2.8.1	Pressure Alarms	16
3.0	THEORY OF OPERATION	17
3.1	Block Diagram	17
3.2	Detailed Circuit Description	17
3.2.1	Power Supply/Battery Charger	17
3.2.2	Microprocessor and Memory	20
3.2.3	Control Line Decoder	20
3.2.4	Sound Generator	20
3.2.5	Watch Dog Timer	22
3.2.6	Displays	22
3.2.7	Switches and the Switch Latch	25
3.2.8	Pressure Transducers and Amplifiers	25
3.2.9	A/D Converter	26
3.2.10	Valves and Valve Relay	26
3.3	Autozero	27
4.0	MAINTENANCE	29
4.1	General Maintenance Information	29
4.2	Access to Parts	29
4.3	Periodic Maintenance	29
4.3.1	Cleaning	29
4.3.2	Inspection	29
4.3.3	Functional and Calibration Checks	30
4.3.4	Calibration	30

4.3.4.1 Transducer Offset 30
4.3.4.2 Common Mode 34
4.3.4.3 Span Adjustment 34
4.3.4.4 Iteration of Adjustments 34
4.3.5 Watchdog Timer Test 34
4.3.6 Leak Testing 35
4.3.7 Power Supply/Battery Charger 35
4.3.8 Battery Voltage Check and Battery Service 35
4.3.9 Overpressure Regulator 36
4.4 Unscheduled Maintenance 36
4.4.1 Troubleshooting Guide 44
4.5 Replaceable Parts 48
4.6 Parts Ordering Information 56
4.7 100V Version 62
4.8 220V Version 63
4.9 240V Version 64
4.10 Storage 65
4.11 Supplied Equipment 66

LIST OF ILLUSTRATIONS

FIGURE TITLE PAGE

2.1 Controls, Indicators & Connectors 10
3.1 Block Diagram 18
3.2 Microprocessor Timing Diagram 21
3.3 WDTSTB Synchronization Timing Diagram 23
3.4 WDT Timing Diagram 24
4.1 A1 Logic PWB Assembly 31
4.2 A2 Power Supply PWB Assembly 33
4.3 Rear Panel Assembly 38
4.4 Front Panel Assembly 39
4.5 Valve Cover Assembly 40
4.6 Internal Assembly Location 41
4.7 Calibration Kit: “T” Hose Assembly 42
4.8 Common-Mode Display Sequence 43
4.9 Schematic Diagram, A2 Power Supply 59
4.10 Schematic Diagram, A1 Logic Board 61
4.12 Alternate Speaker Location 67

TABLE TITLE PAGE

2.1 Alarm Conditions 13
2.2 Hardware Malfunction Displays 15
4.1 Switch Functions & Display Indications in the Calibration Mode 32
4.2 Expected Test Point Readings 37

GENERAL INFORMATION

SECTION 1.0

A.T.S. 1500 TOURNIQUET SYSTEM*

1.1 FEATURES

The *A.T.S.* 1500 Tourniquet is an automatic, microprocessor-based pneumatic tourniquet system. Its features include:

- The ability to control two cuffs in a Bier Block or Bilateral procedure.
- Microprocessor control prevents loss of occlusion during Bier Block cuff switching.
- Uses dual line tubing and dual port cuffs to facilitate sensing cuff pressure from one line and supplying air to pressurize the cuff via the other.
- Built in battery charger and charging indicator.
- Precision pressure transducers in conjunction with a microprocessor based control system.
- Built-in inflation time alarm system to alert the operating room staff when the anticipated cuff inflation time has been reached. This system also provides a convenient means to monitor and record total inflation time.
- Large, bright LED displays for easy viewing from a distance.
- Self-testing of alarm tones, displays, system calibration, and certain portions of the hardware and software each time the unit is turned on. In addition, some self-testing occurs continuously during normal operation.
- Automatic zeroing of pressure transducer circuits to compensate for system drift.
- A variety of audible and visual alarms to alert the user to abnormal conditions including sensed pressure not within acceptable limits, time alarm, battery voltage low, and hardware failure. For certain types of equipment malfunctions, the unit will display error messages that identify the cause of the error, thus reducing fault isolation time.
- An alarm silence switch to permit silencing of most alarm tones for 30 seconds.
- Simple calibration that may be performed without disassembly.
- Modular construction for ease of maintenance and repair.
- Portable and designed to be mounted on existing I.V. poles.

---

*U.S. Patents B1 4,469,099; 4,520,820; 4,548,198; 4,573,888

1.2 SPECIFICATIONS

Line Voltage Range:
105-130 VAC, 50/60 Hz
For other available voltages See Pgs. 58-62.
Line Current:
485 mA RMS Maximum
300 mA RMS Nominal
Input Power:
58 W Maximum
36 W Nominal
Battery Type:
Rechargeable, Sealed Lead Acid, 12 VDC, 2.3 AH
Battery Discharge Time:
Unit will operate on battery power for 15 minutes (minimum with fully charged battery).
Battery Recharge Time:
24 hours (Maximum)
Power Cord:
Type SJT, AWG 18, 13 ft. 2 in. (4.01m)
Power Plug:
Hospital Grade, 3 prong straight blade, 15 A
Line Protection:
0.5 A, 250 V, 5 x 20 mm SLO-BLO Fuse
Cuff Pressure Range:
50-475 mmHg
Pressure Accuracy:
± 5 mmHg (50-475 mmHg)
Pressure Regulation:
± 6mm of Set Point
(10 second average under not transient conditions without external leaks)
Maximum Pressure:
475 mmHg (Normal Operation)
600 mmHg (Internally Limited)
Time Alarm Set Ranges:
0-240 min.; 1 min. increments
Timer Accuracy:
0.25% ± 1 sec.
Internal Diagnostics:
Program, Memory, Watchdog Timer, Transducer Calibration, Improper Valve Actuation.
SIZE:
Height:
16.13 in. (41.0 cm)
Width:
8.75 in. (22.3 cm)
Depth:
7.1 in. (17.9 cm) (including 2 in. clamp)
WEIGHT:
19.8 Lbs (9 Kg)

ALARMS:

CONDITION:	VISUAL INDICATION:	AUDIBLE TONE:
Over Pressure	Pressure Display & Cuff LED Flashes	996 Hz
Under Pressure	Pressure Display & Cuff LED Flashes	996 Hz
Sustained Leak	Pressure Display & Cuff LED Flashes	996 Hz
Exceeded Set Time	Time Display Flashes	488 Hz
Battery Voltage Low	Message On Time Display	244 Hz (Modulated)
Hardware Failure	Failure Messages Appear On Time & Pressure Displays	996 Hz
Cuff Not Deflated	Failure Message Appears On Time & Pressure Displays	966 Hz

CONTROLS:
On/Standby Switch:
Control to apply power to unit.
Pressure Touch-Switches:
Controls to increase or decrease the pressure setpoint.
Time Touch-Switches:
Controls to increase or decrease the time alarm setpoint.
Cuff Touch-Switches:
Controls to inflate or deflate the main cuff and/or the second cuff.
Alarm Silence Switch:
Control to allow operator to manually silence certain alarm tones for 30 seconds.

DISPLAYS:
Pressure:
Red LED Display for Pressure Setting, Sensed Cuff Pressure, and Hardware Failure Condition Messages.
Time:
Red LED Display for Time Alarm Setpoint, Elapsed Time, and Hardware Failure Condition Messages.

Main Cuff Light:
Yellow light bar to indicate inflation of the main cuff or pressure alarm in the main cuff when flashing in conjunction with the Pressure Display.
Second Cuff Light:
Yellow light bar to indicate inflation of the second cuff or pressure alarm in the second cuff when flashing in conjunction with the Pressure Display.
Battery Charging Light:
Yellow light bar to indicate that the backup battery is receiving a charge.
SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

1.3 INTENDED USE

The *A.T.S.*1500 Tourniquet System is intended to be used by qualified medical professionals to temporarily occlude blood flow in a patient's extremities during surgical procedures on those extremities. Tourniquets have been found useful in producing a bloodless operating field in surgical procedures involving the extremities including:

Reduction of certain fractures
Kirschner wire removal
Tumor and cyst excisions
Subcutaneous fasciotomy
Nerve Injuries
Tendon Repair
Bone Grafts
Total wrist joint replacement
Replacement of joints of the fingers
Knee joint replacements
Amputations
Replantations

WARNING: Do not use tourniquet cuffs to control the distal flow of CO_2 or any other gases used as a distention media. Tourniquet cuffs have not been evaluated for safety or effectiveness in controlling gas flow beyond the surgical site during arthroscopic insufflation procedures. Possible effects of using a tourniquet cuff in this manner include serious subcutaneous emphysema proximal to the cuff.

1.4 CONTRAINDICATIONS

The medical literature lists the following as possible contraindications. However in every case the final decision whether to use a tourniquet rests with the attending physician.

Open fractures of the leg
Post-traumatic lengthy hand reconstruction
Severe crushing injuries
Elbow surgery (where there is concomitant excess swelling)
Severe hypertension
Skin grafts in which all bleeding points must be readily distinguished
Compromised vascular circulation, e.g., peripheral artery disease
Diabetes mellitus
The presence of sickle cell disease is a relative contraindication. (See Precautions in Use)

The use of a tourniquet should be avoided in patients who are undergoing secondary or delayed procedures after immobilization.

1.5 PRECAUTIONS IN USE

■ The tourniquet system must be kept well calibrated and in operable condition. Accessories should be checked regularly for leaks and other defects.

■ The tourniquet cuff should never be punctured; therefore towel clips used near the system must be handled with special care. Cuffs with inner rubber bladders must be completely enclosed by the outer envelope to preclude ballooning and possible rupture of the bladder. Cleaning and assembly instructions of the cuff manufacturer should be followed carefully.

■ Do not use an elastic bandage for exsanguination in cases where this will cause bacteria, exotoxins, or malignant cells to spread to the general circulation, or where it could dislodge thrombi that may have formed in the vessels.

■ The tourniquet cuff must be applied in the proper location on the limb, for a "safe" period of time, and within an appropriate pressure range. Never apply a tourniquet over the area of the peroneal nerve or over the knee or ankle. Do not readjust an already inflated cuff by rotating it because this produces shearing forces which may damage the underlying tissue.

■ Prolonged ischemia may lead to temporary or permanent damage to tissues, blood vessels, and nerves. Tourniquet paralysis may result from either excessive or insufficient pressure. The latter may be more dangerous, resulting in passive congestion with possible irreversible functional loss. Prolonged tourniquet time can also produce changes in the coagulability of the blood with an increase in clotting time.

■ Inflation must be done rapidly to occlude arteries and veins as near simultaneously as possible, and to avoid return of blood into the limb.

- No known safe limit to the number of aeration intervals during prolonged tourniquet time has been established. Tissue aeration periods should last at least 10 and preferably 15 minutes the first time and 15 to 20 minutes subsequently.
- During exsanguination with an Esmark bandage, a safe zone of uncovered skin about one inch wide should be maintained between cuff and bandage. This is necessary to prevent the cuff from slipping distally. Cuff effectiveness is also reduced if the bandage is wound up to the cuff. Careful and complete exsanguination reportedly prolongs pain-free tourniquet time. However, partial exsanguination may be desirable in certain cases where the residual blood will aid in the visualization and identification of vascular structures. In the presence of infection and painful fractures, after the patient has been in a cast, and in amputations because of malignant tumors, exsanguination before tourniquet application must be done without the use of an elastic bandage by elevating the limb for 3 to 5 minutes.
- In case of failure, the tourniquet cuff must be fully deflated and the limb exsanguinated again before reinflation. Reinflation over blood-filled vasculature may lead to intravascular thrombosis.
- Tourniquet users must be familiar with the inflation-deflation sequence when using a dual-cuff tourniquet, or two tourniquet cuffs together, so that the wrong tourniquet will not be released accidentally.
- Test for hemoglobin type and its level before using a tourniquet on patients with sickle-cell anemia. When the tourniquet is used for these patients, the limb should be carefully exsanguinated and the PO2 and pH should be closely monitored.
- Select the proper cuff size to allow for an overlap of about 3 to 6 inches. Too much overlap may cause rolling and wrinkling and lead to localized excessive pressure build-up. The skin under the tourniquet cuff must be protected from mechanical injury by smooth, wrinkle-free application of the cuff. If the tourniquet cuff is applied over any material that may shed loose fibers (such as Webril) the fibers may become embedded in the contact closures and reduce their effectiveness. In most cases padding has not been found necessary and may cause additional wrinkles. The deflated cuff and any underlying bandages should be completely removed as soon as tourniquet pressure is released. Even the slightest impedance of venous return may lead to congestion and pooling of blood in the operative field.
- If skin preparations are used preoperatively, they should not be allowed to flow and collect under the cuff where they may cause chemical burns.
- Whenever the tourniquet cuff pressure is released, the wound should be protected from blood surging back by applying pressure dressings and, if necessary, elevating the limb. Transient pain upon tourniquet pressure release can be lessened by elevation of the limb. If full color does not return within 3 to 4 minutes after release, the limb should be placed in a position slightly below body level.
- Whenever infiltration anesthesia is used, it is recommended that the tourniquet remain inflated for at least 20 minutes from the time of injection. For a procedure requiring only a few minutes, too rapid release of the anesthetic agent can be prevented by reinflating the tourniquet several times. Deflation periods should last about 15 seconds; reinflation periods about 30 to 45 seconds.

1.6 ADVERSE EFFECTS

A dull aching pain (tourniquet pain) may develop throughout the limb following use.

Pathophysiologic changes due to pressure, hypoxia, hypercarbia, and acidosis of the tissues occur and become significant after about 1-1/2 hours of tourniquet use. Symptoms of tourniquet paralysis are motor paralysis and loss of sense of touch, pressure, and proprioceptive responses.

Intraoperative bleeding may be caused:

1. By the slight impeding effect exerted by an unpressurized cuff (and its padding, if used), which prevents venous return at the beginning of the operation.
2. By blood remaining in the limb because of insufficient exsanguination.
3. By inadequate tourniquet pressure (between systolic and diastolic blood pressure of the patient), or slow inflation and deflation, all of which allow arterial blood to enter while preventing venous return.
4. By blood entering through the nutrient vessels of the long bones, such as the humerus.

INSTALLATION & OPERATING INSTRUCTIONS

SECTION 2.0

A.T.S. 1500 TOURNIQUET SYSTEM

2.1 INITIAL INSPECTION

Unpack the *A.T.S.* 1500 Tourniquet upon receipt and physically inspect the unit for any obvious damage that may have occurred during shipment. We recommend that this inspection be performed by a qualified biomedical engineer or other person thoroughly familiar with electronic medical devices. If the unit is found to be damaged, notify the carrier and your Zimmer representative immediately. If the initial inspection results are satisfactory, a functional and calibration check should be performed.

2.2 FUNCTIONAL AND CALIBRATION CHECK

The unit shall produce the results explained in the following steps, exactly as indicated. Failure to do so indicates that the device is not to be used until necessary repairs are made.

1. Connect the power plug of the unit to a source of power compatible with the ratings listed on the unit's nameplate.
2. Move the ON/STANDBY switch to the ON position and observe the following sequence:
   a) The word SELF appears on the PRESSURE display; the word TEST appears on the TIME display;
   b) A series of zeros and asterisks appear on the PRESSURE and TIME displays; the yellow BACKUP BATTERY CHARGING Light is illuminated; both yellow CUFF lights illuminate;
   c) The Alarm Silence Switch illuminates;
   d) The unit emits a high pitched tone (996 Hz); then a medium pitched tone (448 Hz); then a low pitch tone (244 Hz);
   e) The tones are silenced; the Alarm Silence Switch glows more brightly for a moment then is extinguished;
   f) Both CUFF lights are extinguished; the TIME display reads 0; the PRESSURE display reads sensed pressure (near zero).
3. Test the PRESSURE setpoint system as follows;
   a) Press and hold the PRESSURE INCREASE (or DECREASE) touch-switch;
   b) The PRESSURE display will blank momentarily;
   c) The PRESSURE display reads "200," the default pressure setpoint, for approximately 1.5 seconds;
   d) The PRESSURE display again blanks momentarily;
   e) The PRESSURE display increases (or decreases) by units of one, until 210 (or 190), thus altering the pressure setpoint in increments of 1 mmHg;
   f) The PRESSURE display again blanks momentarily;
   g) The PRESSURE display increases (or decreases) by units of five to a maximum of 475 (or a minimum of 0) mmHg;
   h) Releasing the touch-switch causes the display to blink twice, then display sensed pressure (near zero);
   i) Once again press the PRESSURE INCREASE (or DECREASE) touch-switch for approximately 1 second; after momentary blanking, the PRESSURE display should read the last setting from step g) above;
   j) Release the PRESSURE touch-switch.
4. Test the TIME alarm system as follows:
   a) Press and hold the TIME INCREASE (or DECREASE) touch-switch;
   b) The TIME display will blank momentarily;
   c) The TIME display will read "60," the default alarm setting, for approximately 1.5 seconds;
   d) The TIME display will again blank momentarily;
   e) The TIME display increases (or decreases) by units of one until 70 (or 50), thus altering the time

alarm setpoint in increments of 1 minute;

f) The TIME display again blanks momentarily;

g) The TIME display increases (or decreases) by units of five to a maximum of 240 (or a minimum of 0) minutes of inflation before the alarm sounds;

h) Releasing the touch-switch causes the display to blink twice then display elapsed time (zero);

i) Press the TIME INCREASE (or DECREASE) touch-switch for approximately one second;

j) After momentary blanking, the TIME display should read the last setting from step g) above;

k) Release the TIME touch-switch.

5. Calibration Check

NOTE: During the power-up diagnostic self-tests, described above, the unit completes an autozero of the pressure transducers and amplifiers. This autozero is performed by momentarily connecting the pressure transducers to the atmosphere and by taking the resulting pressure readings as zero pressure. An out of range reading would indicate an amplifier is out of calibration and/or a hardware problem exists and the unit would go into a CAL FAIL state. Completion of the self checks indicates no out of range reading was detected and that the unit is sufficiently calibrated for use. Even though the unit completes this check during power-up, the following quantitative check is recommended at regular intervals. See Section 3.3 for more information on autozero.

a) Connect a manometer, known to be in good working order, to the main cuff connector. (A "T" hose assembly will normally be required to make this connection. A suitable "T" hose assembly is available from Zimmer see Figure 4.7).

NOTE: In addition to the manometer, there must be a cuff or other volume attached to the "T" hose assembly to insure the tourniquet will operate properly.

CAUTION: The *A.T.S.* 1500 Tourniquet is capable of developing pressures greater than some manometers can measure. Select the calibration pressure to be within the range that can be measured by your manometer.

b) Set the desired test pressure using the PRESSURE increase and/or decrease touch-switches. A test pressure of 250 mmHg is recommended.

c) Press the MAIN CUFF INFLATE touch-switch.

OBSERVE: The manometer reading should increase to within 6 mmHg (plus or minus the accuracy of the manometer) of the pressure setpoint. It is suggested that a record be kept of the results of each calibration check to identify trends.

d) If the unit does not inflate the manometer to within 6 mmHg of the setpoint, please see Section 4.3.4, Calibration.

e) Repeat steps a thru d for the SECOND CUFF.

6. Under Pressure Alarm Check

Create a leak in the main cuff while it is inflated. Make the leak large enough that even though the unit will be attempting to maintain pressure, the pressure still falls more than 15 mmHg below setpoint. Observe:

a) The PRESSURE display and MAIN CUFF light begin to flash.

b) The Alarm Silence Switch illuminates.

c) After approximately 1 second, an audible tone will sound announcing the pressure-out-of-limits condition. This delay is used to preclude nuisance alarms.

Stop the leak and observe that the pressure returns to within limits, the audible tone ends, and the Alarm Silence Switch light extinguishes.

7. Leak Test

The *A.T.S.* 1500 Tourniquet is capable of keeping a cuff with a substantial leak inflated. Naturally it is desirable to keep plumbing leaks to an absolute minimum. For this reason, a check for significant leakage is recommended.

Connect both pairs of cuff connectors to cuffs. It would be best if the cuffs were the ones that are most commonly used. The cuffs should be wrapped around some object (cylinder, coffee can or something similar) or tightly around themselves. Set the desired pressure to 475 mmHg. Ensure that all connections are snug. Inflate the main cuff and allow the pressure to stabilize. Now move the ON/STANDBY switch to the STANDBY position. After 10 minutes, move the switch back to the ON position. Operation will resume under Cuff Inflated Start-up Conditions (see Section 2.5 part 3 for a description). Cancel the alarm using the ALARM SILENCE pushbutton. Activate either PRESSURE touch-switch for one second and view the current pressure setpoint. This value should be at least 400 mmHg. Values less than this indicate an unacceptable leak rate, and the source of the leak should be traced and corrected. The first connection to check should be the Luer connectors of the cuffs. The connectors may be tested by submersing them in water, using a bubble solution (soap and water mixture 50/50), or by testing different cuffs and/or cuff hose combinations. Elimination of the cuff and cuff hoses as the source of the leak points to the leak being internal and the unit should be removed from service until it has been repaired. Repeat same procedures for second cuff.

NOTE: Luer connectors have a finite life. Whenever a Luer connector is used, the two mating parts should fit together snugly but not requiring all of your strength to connect or disconnect. If a Luer connector is found to leak, it must be replaced.

8. If all of the previous seven checks were successful, the *A.T.S.* 1500 Tourniquet is ready for use.

2.3 INSTALLATION

The *A.T.S.* 1500 Tourniquet is designed to be mounted on any stable I.V. pole. The adjustment range of the pole clamp on the right side of the unit will accommodate pole diameters of 0.5 to 1.5 inches (1.25 to 3.8 cm).

The power cord of each unit is equipped with a restraining strap that should be attached to the bottom of the I.V. pole in use. This is intended to minimize the likelihood of upsetting the pole mounted unit in the event of an inadvertant jerk on the power cord.

Connect the power cord of the unit to a properly polarized and grounded power source whose voltage and frequency characteristics are compatible with those listed on the nameplate of the unit.

The *A.T.S.* 1500 Tourniquet is now ready for use.

2.4 CONTROLS, INDICATORS, AND CONNECTORS

Refer to Figure 2.1 for the locations of the unit's controls, indicators, and connectors. Their primary functions are described below.

1. POWER SWITCH — With the unit's power cord connected, this switch turns the unit on and off.

2. PRESSURE SETTING SWITCHES — To view the current pressure setting, depress either pressure setting touch-switch for up to 1.5 seconds. The PRESSURE display will blank, display the pressure setting for a moment, and then return to displaying the current cuff pressure when the touch-switch is released.

To change pressure setting, depress and hold the increase (+) or decrease (–) touch-switch until the desired setting is reached. The setting will change in increments of 1 mmHg for the first 10 mmHg, and then in increments of 5 mmHg thereafter until the touch-switch is released or the limits of 0 or 475 mmHg are reached.

Other — See Section 4.3.4 of this manual for functions of the switches during Calibration.

3. TIME ALARM SWITCHES — To view the current time alarm setting, depress either time alarm touch-switch for up to 1.5 seconds. The TIME display will blank, display the time alarm setting for a moment, and then return to displaying the current inflation time when the touch-switch is released.

To change time alarm setting, depress and hold the increase (+) or decrease (–) touch-switch until the desired setting is reached. The setting will change in increments of 1 min. for the first 10 min. and then in increments of 5 minutes thereafter until the touch-switch is released or the limits of 0 or 240 minutes are reached.

The accumulated inflation time may be set to zero by depressing the time increase and decrease touch-switches simultaneously for two seconds. This would enable the unit to be used for multiple procedures at the same pressure setting without turning off the power (and thus erasing the previously stored pressure setpoint).

Other — See Section 4.3.4 of this manual for functions of these switches during Calibration.

4. INFLATE/DEFLATE SWITCHES — Inflation or deflation of the cuff(s) is accomplished by depressing the appropriate touch-switch. For greater safety, the DEFLATE touch-switch must be depressed longer than one second before deflation commences. When the main cuff is inflated, the MAIN CUFF light is on, and when the second cuff is inflated, the SECOND CUFF light is on.

NOTE: It is not possible to deflate one cuff when the other cuff is inflating.

Other — See Section 4.3.4 of this manual for functions of these switches during Calibration.

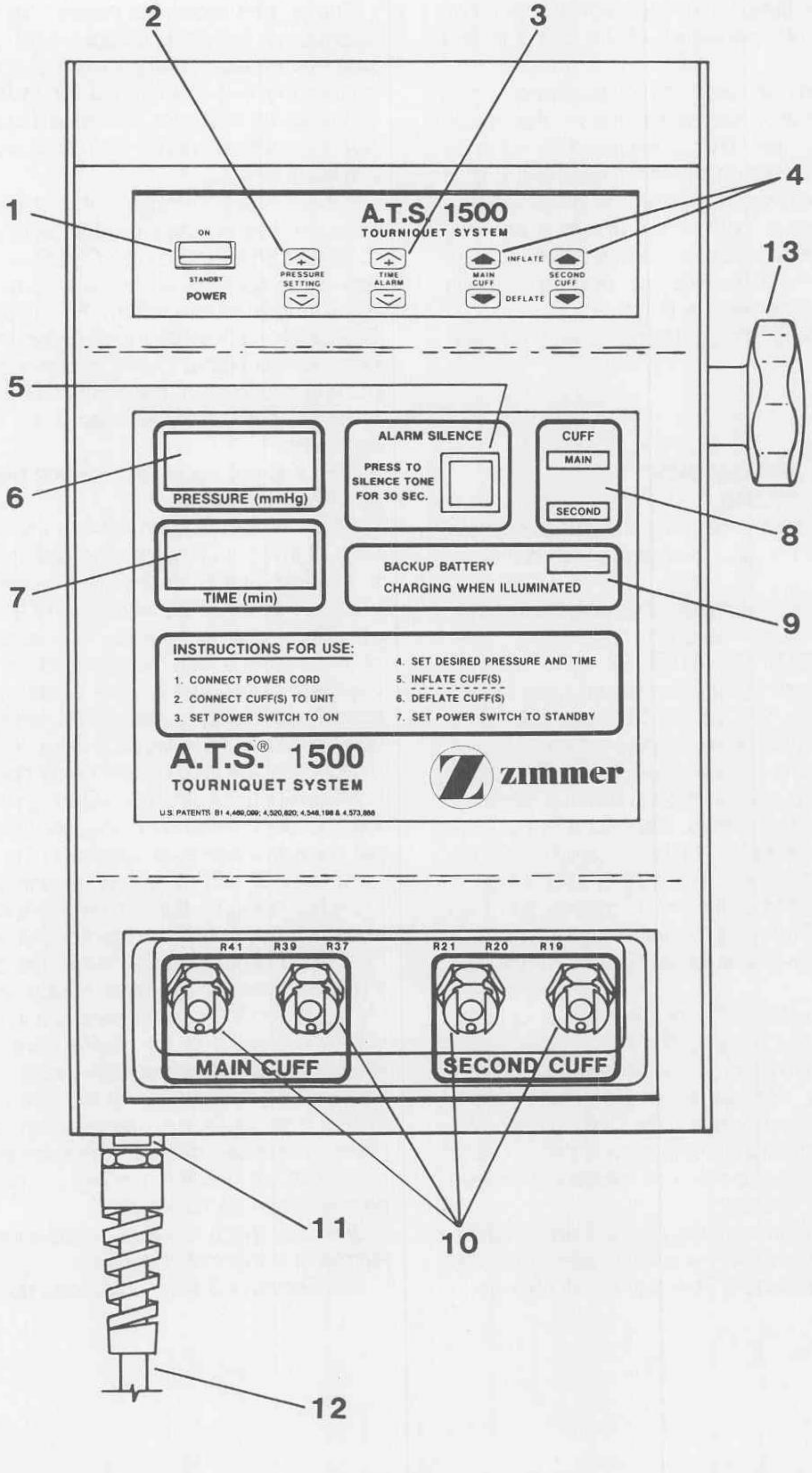
5. ALARM SILENCE SWITCH — This lighted push-button switch will light when any of a number of alarm conditions exist. The audible tone associated with most of these alarms may be silenced for 30 seconds by depressing this switch. The push-button will remain lighted until the alarm conditon is corrected. In general, when an alarm condition is a result of an internal circuit malfunction, the tone cannot be silenced by this switch.

6. PRESSURE DISPLAY — During normal operation, with no touch-switches being depressed, this display will show the pressure sensed in the cuff(s) over the range of 0 to 475 mmHg. With one cuff inflated and the other deflated, the display will show the pressure in the inflated cuff. The desired pressure setting may be viewed on this display when the pressure setting touch-switches are operated in accordance with item 2 above. When the sensed pressure in the cuff(s) is not within 15 mmHg of the desired pressure setting, or when there is a sustained leak present as described in Section 2.8.1, this display will flash the sensed pressure. When both cuffs are inflated, an average of the pressures sensed in the cuffs will be displayed. When both cuffs are deflated, the highest of the two sensed pressures will be displayed.

See Section 2.8 for other possible indications during alarms or abnormal conditions.

See Section 4.3.4 for indications during Calibration.

Figure 2.1 Controls, Indicators & Connectors


2
3
4
1
13
A.T.S. 1500
TOURNIQUET SYSTEM
ON
STANDBY
POWER
PRESSURE SETTING
TIME ALARM
INFLATE
MAIN CUFF
SECOND CUFF
DEFLATE
5
ALARM SILENCE
PRESS TO SILENCE TONE FOR 30 SEC.
CUFF
MAIN
SECOND
6
PRESSURE (mmHg)
8
7
TIME (min)
BACKUP BATTERY
CHARGING WHEN ILLUMINATED
9
INSTRUCTIONS FOR USE:
1. CONNECT POWER CORD
2. CONNECT CUFF(S) TO UNIT
3. SET POWER SWITCH TO ON
4. SET DESIRED PRESSURE AND TIME
5. INFLATE CUFF(S)
6. DEFLATE CUFF(S)
7. SET POWER SWITCH TO STANDBY
A.T.S.® 1500
TOURNIQUET SYSTEM
zimmer
U.S. PATENTS B1 4,469,099; 4,520,820; 4,548,198 & 4,573,886
R41
R39
R37
R21
R20
R19
MAIN CUFF
SECOND CUFF
11
10
12

7. TIME DISPLAY — During normal operation, with no touch-switches being depressed, this display will show the inflation time of the cuff(s) in 1 min. increments up to a maximum of 240 minutes. The time alarm setting may be viewed on this display when the time alarm touch-switches are operated in accordance with item 3 above. If the inflation time has exceeded the time alarm setting, the display will flash the current inflation time.

See Section 2.8 for indications during alarms or abnormal conditions.

See Section 4.3.4 for indications during Calibration.

8. CUFF LIGHTS — Indicates which cuff or cuffs are active. Lights flash when a pressure alarm occurs to indicate which cuffs to check.

9. BACKUP BATTERY LIGHT — This light is illuminated when the backup battery is charging in one of the higher level charging states. The light will not be illuminated when the power cord has been disconnected for more than a few seconds or if there is no battery in the unit, or if the battery is incapable of receiving a charge. **The light may go off for varying intervals, up to a few minutes, if the battery is fully charged or the battery charger has just made a transition between charging states. The light will also be off while the trickle charger is attempting to recover a severely discharged battery.** Refer to Section 3.2.1 for battery charger operation.

10. CUFF CONNECTORS — Ports to connect tubing to cuff(s).

11. PRIMARY LINE FUSE — Protects power line against internal overloads. This fuse should be replaced only with one of the same type and rating.

12. POWER CORD — Supplies primary AC power to unit when connected to appropriate receptacle.

13. POLE CLAMP — Adjustable clamp to mount the unit on an I.V. pole.

2.5 SINGLE CUFF OPERATION

1. With the ON/STANDBY switch in the STANDBY position, connect the power cord to an electrical power source that is compatible with the ratings listed on the nameplate of the device.

2. Connect a dual port cuff to the unit at the main cuff connectors.

3. Set the ON/STANDBY switch to the ON position. The unit will execute a self-check diagnostic test as described in Section 2.2 of this manual. Successful completion of the self-check indicates the unit is ready to use.

CAUTION: Special note should be made of the fact that if either cuff is pressurized to 50 mmHg or more during power-up, the A.T.S. 1500 Tourniquet will declare it an abnormal start-up sequence. It will assume that a surgical procedure is in process and will adopt the higher of the pressures sensed in each cuff as the new set point. It will automatically go into the inflation mode and regulate either or both cuffs (depending on whether either or both had pressures in excess of 50 mmHg) to the new set point. To alert the operator of this condition, the unit will sound a high pitched tone and illuminate the Alarm Silence Switch light. The operator should immediately check the pressure set point and readjust it if necessary. The alarm is cleared by depressing the Alarm Silence Switch.

4. In the absence of operator action, the unit adopts preset values for desired cuff pressure and inflation time alarm of 200 mmHg and 60 minutes respectively. These values may be observed on the displays by pressing the PRESSURE and/or TIME increase (+) or decrease (−) touch-switch for up to 1.5 seconds.

For each patient, tourniquet pressure should be set to the minimum effective pressure. The minimum effective pressure should be determined by taking into account factors such as: whether the cuff is to be applied to an upper or lower limb; whether the limb is normal, hyperthrophied, or obese; the patient's preoperative systolic pressure; and the maximum anticipated rise in systolic pressure during the procedure.

Set the desired cuff pressure by pressing and holding the PRESSURE increase (+) or decrease (−) touch-switch until the desired setting is reached. Similarly set the desired inflation time alarm using the TIME increase (+) or decrease (−) touch-switches.

5. Prepare the patient in accordance with your established procedures and cuff manufacturer's instructions. The precautions of Section 1 and the following are offered as a guide to assist in this process.

In most cases a tourniquet cuff should be applied at the widest part of the limb to allow as much tissue as possible to lie between the cuff and any nerves or vascular structures susceptible to damage. The optimum positions are the upper arm and the proximal third of the thigh. In certain cases of fore-foot surgery, the tourniquet cuff can be applied around the calf or to the area proximal to the malleoli. For emergency surgery of the hand, a sufficiently small tourniquet can be inflated around the wrist.

Apply a leak-free tourniquet cuff smoothly without wrinkles. The valve stem and tube connections should be placed so that the tubing will not be kinked when the limb is positioned for surgery. The limb is then prepared and draped for surgery. The viability of the skin and deeper tissues should be established prior to exsanguination of the limb and tourniquet inflation.

Exsanguinate the limb by elevating it for a minimum of 2 minutes and wrapping it, starting from the distal and progressing to the proximal part, using an Esmark, Martin, or elastic bandage. The bandage should come up approximately to one inch from the edge of the tourniquet cuff. The elastic bandage is removed following inflation of the cuff. If regional anesthesia is being used, the anesthetic agent or nerve block is then administered.

The tourniquet time depends greatly on the patient's anatomy, age, and absence of vascular disease. The surgeon will determine when the tourniquet is to be inflated, to what pressure, for how long, whether to allow for intermittent aeration of tissue by deflating the cuff for 10 to 15 minutes, and to what point in the operation the tourniquet should be released. In many operating rooms, it is customary to note prominently the time of inflation, and to warn the surgeon after a certain time period so that he or she can assess the need for further tourniquet time.

There is general agreement that, for reasonably healthy adults, about one and a half hours is "safe" and two hours should not be exceeded without releasing the tourniquet to allow the underlying tissue to "breathe" for about 15 to 20 minutes. During this time, the limb should be elevated about 60 degrees, and steady pressure should be applied to the incision with sterile dressings.

Under optimum conditions, the tourniquet cuff can be kept inflated until the final compression dressings are in place. Postoperative swelling is then kept to a minimum.

6. The cuff is inflated by pressing the red MAIN CUFF INFLATE touch-switch. The unit will pressurize the main cuff to the desired pressure and start the inflation time clock. The MAIN CUFF light will illuminate to indicate cuff activation. If the unit cannot pressurize the cuff to within 15 mmHg of setpoint in less than 30 seconds, a pressure alarm will be sounded. See Section 2.8 for information about possible alarm conditions.

7. At the end of the procedure, deflate the cuff by pressing the MAIN CUFF DEFLATE touch-switch. The MAIN CUFF light will go out, the PRESSURE display will show the deflation of the cuff, and the inflation time clock will stop. Record the elapsed inflation time if desired.

It is best to remove the tourniquet cuff and any underlying bandages immediately following final deflation. The time of tourniquet cuff removal should be noted, and the circulation of the limb should be checked.

8. Set the ON/STANDBY switch to the STANDBY position only after the pressure display indicates less than 50 mmHg.

2.6 DUAL CUFF OPERATION

Operation of the unit is identical to Single Cuff operation (see Section 2.5) except for the following points;

1. Both dual port cuffs are connected at the bottom of the unit.

2. The CUFF lights indicate the cuff that is active. (i.e. If both CUFF lights are illuminated then both cuffs are inflated.)

3. During a pressure alarm the flashing CUFF light indicates the cuff(s) to check.

4. Deflation of one cuff will not be permitted while the other cuff is inflating.

5. When inflating a cuff with the other cuff already inflated, the unit will continuously check the original cuff to insure that the pressure is within allowable limits. The unit will stop its inflation, and maintain the original cuff to within 10 mm of setpoint before returning to the inflating cuff. This is to insure that at least one cuff maintains occlusion at all times. If there is a significant leak in the original cuff, this feature could cause the inflation rate of the subsequent cuff to be longer, perhaps even causing the 30 second inflation alarm to sound. The display shows the pressure in the inflating cuff so as to allow the operator to view the progress of inflation.

6. When deflating a cuff with the other cuff remaining inflated, the display shows the pressure in the cuff that remains inflated.

7. When both cuffs are inflated, the display indicates an average of the pressures sensed in the two cuffs. If one has a significant leak (as described in section 2.8), or a sustained leak (as described in section 2.8.1) a pressure alarm may be sounded. Regulation of dual cuffs as one commences when the second cuff to be inflated is within 3mm of set point while the initially inflated cuff remains within 10mm of set point. Subsequently, when neither cuff pressure is 30mm or more below set point, the average of the pressures sensed

Table 2.1 Alarm Conditions

CONDITION	AUDIBLE TONE	PRESSURE DISPLAY	TIME DISPLAY	ALARM SILENCE PUSHBUTTON	APPROPRIATE ACTION/REMARKS
1. PRESSURE LOW: 15 mmHg or more below desired setting.	STEADY HIGH PITCH	FLASHING SENSED CUFF PRESSURE		LIT	This condition is generally caused by a leak in the system or a tubing occlusion. All lines and connections should be checked.
2. PRESSURE HIGH: 15 mmHg or more above desired setting.	STEADY HIGH PITCH	FLASHING SENSED CUFF PRESSURE		LIT	Normally caused by transient conditions such as controller overshoot, patient movement or tube occlusion. This condition for an extended period would indicate a hardware failure and the *A.T.S.* 1500 should be replaced.
3. SUSTAINED LEAK	STEADY HIGH PITCH	FLASHING SENSED CUFF PRESSURE		LIT	A substantial leak has been continuously present for more than 9 seconds.
4. INFLATION TIME IN EXCESS OF SETTING	STEADY MEDIUM PITCH		FLASHING ELAPSED TIME	LIT	Time should be set to new value.
5. LOW BATTERY VOLTAGE	STEADY LOW PITCH		BAT LOW PLUG IN	LIT	Unit needs to be plugged in.
6. CUFF PRESSURIZED DURING POWER UP This will occur if, for example, the unit is turned off and back on without deflating the cuff.	STEADY HIGH PITCH			LIT	If a cuff pressure is 50 mmHg or greater at the time that the POWER switch is set to ON the system assumes that a procedure is in progress. It adopts the sensed pressure of the cuff(s) as the desired setting and sounds the alarm to notify the operator that it has done so. The operator should immediately check the pressure setting to see if it needs to be reset to a different value.
7. UNIT OUT-OF-CALIBRATION	STEADY HIGH PITCH	CALM OR CAL2	FAIL	LIT	Pressure in error by at least 6 mmHg, CALM indicates main cuff amplifier out of calibration, CAL2 indicates 2nd cuff amplifier out of calibration.
8. INSUFFICIENT BATTERY VOLTAGE	STEADY HIGH PITCH	BAT	FAIL	LIT	The battery voltage has reached a level that is too low to insure reliable operation. Plug unit in and cycle power switch.
9. PROCESSOR ERROR	STEADY HIGH PITCH	WDT ROM RAM MATH VALV	FAIL	LIT	Hardware has malfunctioned and failed self check. The unit is automatically disabled, unresponsive to any commands and not usable. Turn it off. See Operator's & Service Manual for specific meanings of these codes.
10. CUFF NOT DEFLATED.	STEADY HIGH PITCH	SENSED PRESSURE	MAIN or 2ND NOT DEFL	LIT	Pressure in the deflated cuff is greater than 10mmHg. Check for hose kinks or other defects. Disconnect cuff hose if condition persists.
NON-ALARM CONDITION (Calibration)		CAL	MODE		These indications are related to the Calibration Mode and should not be seen during normal operation. If seen, it suggests that the TIME and PRESSURE DECREASE switches were being depressed at the time that the POWER was set to ON. To get back to normal operation set the POWER switch to STANDBY and then back to ON.
		OFST	R37 or R19		
		MAIN or 2nd	SPAN		
		R41 or R21	CMOD		
		WDT	SLOW		
		Number Between 120 & 140	Number Between 120 & 140		
		Sensed Pressure	247 or R37 or R19 or R39 or R20		
		Sensed Pressure	BURN		
		BAT	VOLT		

NOTE: In addition to the conditions shown, it is conceivable that a malfunction could occur for which the indicators are unintelligible and unpredictable. It is very likely that the valves will be disabled causing the system to hold cuff pressure. It is also likely that a high pitched tone will be sounded under these conditions.

in the individual cuffs is used to control both simultaneously. If thereafter, only one cuff is detected to fall 30mm or more below set point, then the second cuff will be secured while individual attention is given to the low pressure cuff until it is brought to 10mm or less below set point provided that the secured cuff remains not more than 30mm below set point. If during the time that individual attention is being given to the low pressure cuff, the pressure in the secured cuff is detected to go 30mm or more below set point, then the low pressure cuff will be secured and individual attention will be given to the previously secured cuff provided both do not go 30mm or more below set point. The control system will continue to manage the cuffs alternately until such time that one (or both) of them is (are) recovered to not more than 10mm below set point and the other is not more than 20mm below set point before resuming dual cuff regulation simultaneously.

If both cuffs are detected to fall 30mm or more below set point (as they might in the event of the onset of an excessive leak; hose failure, cuff failure, or the like) then the system will attempt to secure both cuffs and commence to manage the cuff deemed to be more likely to be recoverable. The first cuff to be inflated will be the one in which the highest pressure is sensed. If the cuff selected for management under these conditions can be recovered to not more than 20mm below set point, then the system will attempt to inflate the lower pressure cuff until it is not more than 20mm below set point, or until the cuff selected first again falls 30mm below set point. If both recover to not more than 10mm below set point, dual cuff regulation is resumed. If both are recovered to not more than 20mm below set point, but not within 10mm, then the cuff with the lower pressure will be individually brought to no more than 10mm below set point before dual cuff regulation is resumed.

2.7 BIER BLOCK OPERATION

1. Review Sections 2.5 and 2.6, SINGLE CUFF OPERATION and DUAL CUFF OPERATION.
2. The following are suggested cuff connections:
   a) The proximal cuff connected to the red outlined MAIN CUFF connector using the white/red cuff tubing.
   b) The distal cuff connected to the blue outlined SECOND CUFF connector using the white/blue cuff tubing.
3. Follow the cuff inflation sequence adopted by your institution or requested by the surgeon.
4. Remember that deflation of a cuff is not possible while the other is inflating.

2.8 ALARM CONDITIONS

There are a number of conditions for which the *A.T.S.* 1500 Tourniquet will produce a visual and/or audible alarm. Those conditions, indications and appropriate actions are shown in Table 2.1. The appropriate actions indicated are based on the most probable causes and should only be used as a guide. Other causes of alarm conditions may indicate a need for other actions.

In addition to the conditions shown in Table 2.1, it is conceivable that a malfunction could occur for which the indications are unintelligible and unpredictable. It is very likely that the valves will be disabled causing the system to hold cuff pressure. It is also likely that a high pitched tone will be sounded under these conditions.

Most audible alarm tones may be silenced for 30 seconds by depressing the Alarm Silence pushbutton. The light in the Alarm Silence pushbutton will normally remain lit until the condition that created the alarm has been corrected. At the end of the silence period, tones will be reenabled. Depressing the Alarm Silence switch will cause the alarm tone to be silenced again.

It is possible for more than one alarm condition to be present at any time. In that event, the unit will announce the alarm conditions in sequence. The operator should identify the causes of the alarms and act on the condition that presents the most danger first. Note that the alarm silence switch will silence the audible tones associated with multiple alarm conditions in the same manner that it does for single alarm conditions.

To minimize nuisance pressure alarms that can be caused by vigorous movement of the patient's limbs, a 1.5 second delay has been designed into the tone generator. The pressure display will still flash during the 1.5 second period.

Under certain conditions, such as when a FAIL indication appears in the TIME display or the information that appears in the TIME and PRESSURE displays is unintelligible, the operator should conclude that a hardware failure has occurred rendering the unit unusable. The appropriate action in such an event is to set the ON/STANDBY switch to STANDBY. Since this removes power from the internal circuitry, all commands to the valves and pump will cease which should cause the cuff to hold pressure (in the absence of leaks). Clamp the cuff lines with hemostats or the like and replace the tourniquet. FAIL conditions can only be

Table 2.2 Hardware Malfunction Codes

Pressure Display	Time Display	Audible Tone	Alarm Silence Pushbutton	Meaning of Indications
AMP	FAIL	STEADY HIGH PITCH	LIT	An output of the amplifiers is out of range
BAT	FAIL	STEADY HIGH PITCH	LIT	Battery voltage too low to insure reliable operation
CALM	FAIL	STEADY HIGH PITCH	LIT	Main cuff pressure amplifier out of calibration or CAL valve malfunction
CAL2	FAIL	STEADY HIGH PITCH	LIT	Second cuff pressure amplifier out of calibration or CAL valve malfunction
HEX	FAIL	STEADY HIGH PITCH	LIT	An error in the conversion of a number has occurred in software
MATH	FAIL	STEADY HIGH PITCH	LIT	Result of a math operation was out range
ROM	FAIL	STEADY HIGH PITCH	LIT	Microprocessor failed a ROM memory check
RAM	FAIL	STEADY HIGH PITCH	LIT	Microprocessor failed a RAM memory check
VALV	FAIL	STEADY HIGH PITCH	LIT	An improper combination valve and pump actuations occured
WDT	FAIL	STEADY HIGH PITCH	LIT	Unit failed the watchdog timer hardware check either during SELF TEST or during normal operation

reset by setting the ON/STANDBY switch to STANDBY. In the event that a FAIL shutdown was caused by transient condition, it may be possible to resume normal operation by first setting the ON/STANDBY switch to STANDBY and then setting it back to ON. Please read the special CAUTION note in 2.5.3 for abnormal startup.

The definitions for the hardware failure messages identified in conditions 7 through 9 of Table 2.1 are delineated in Table 2.2.

2.8.1 PRESSURE ALARMS

A pressure alarm will occur when then pressure in a cuff is more than 15 mmHg from the pressure setpoint.

It is also possible for a cuff to have a leak that is substantial but which the unit can compensate for by continual pumping. This type of leak could be due to a pin hole in a cuff bladder, or a loose pneumatic fitting. This type of leak could progress into a total failure of a cuff to hold pressure. To alert the operator that a substantial leak is present, a pressure alarm is declared when this type of leak is continuously present for more than 9 seconds. If a pressure alarm occurs, and the displayed pressure is not more than 15 mmHg from setpoint, then this type of substantial leak has been detected and all cuffs and pneumatic fittings should be checked for leaks.

THEORY OF OPERATION

SECTION 3.0

A.T.S. 1500 TOURNIQUET SYSTEM

3.1 BLOCK DIAGRAM

Refer to Figure 3.1

The *A.T.S.* 1500 Tourniquet is a microprocessor controlled automatic tourniquet. The microprocessor takes inputs from various switches, the A/D converter, and the memory and uses this information to generate commands to the outputs (valves, pump, displays, alarm circuitry) in order to regulate cuff pressure. The pump and the six valves control the inflation, deflation, sensing, and calibration of the two tourniquet cuffs and their pressure transducers.

The main and second cuffs are connected to the pump via valves V1 and V3. These valves are open for inflation of the cuffs. For deflation of the cuffs, they are closed and valves V2 and V4 are opened. Valves V5 and V6 connect the pressure transducers to the atmosphere periodically for calibration. Please note the block diagram (Figure 3.1) shows all valves in their off (no power) conditions. Should a condition occur to cause power to fail or should the unit enter a hardware failure mode, the power to the valves and the pump will cease and they will go into a position that prevents internal leaks.

The pressure transducers are connected to the A/D converter via excitation and amplification circuitry. The digitized pressure signals are used by the microprocessor, along with a velocity feedback signal from the pump, to regulate the pressure in the cuff(s). The condition of the +12V power supply is also periodically checked. This voltage represents the true battery voltage when AC power is not present. The unit can thus alarm when the battery voltage becomes low during a loss of AC power or during patient transport.

The Watch Dog Timer is a hardware circuit that monitors a timing signal generated by the microprocessor. Should this signal become abnormal, indicating a problem with either the microprocessor or the software, the Watch Dog Timer circuit cuts off power to the pump and the valves and attempts a hardware interrupt of the microprocessor. If the microprocessor is able to act on the interrupt, a failure message is displayed on the front panel displays and an alarm tone is emitted.

3.2 DETAILED CIRCUIT DESCRIPTION

The following is a detailed description of the operation of the tourniquet's electronics on a circuit by circuit basis. The text is supplemented by the schematics of the Power Supply and the Logic Board found in Figures 4.9 and 4.10 respectively.

3.2.1 Power Supply/Battery Charger (A2)

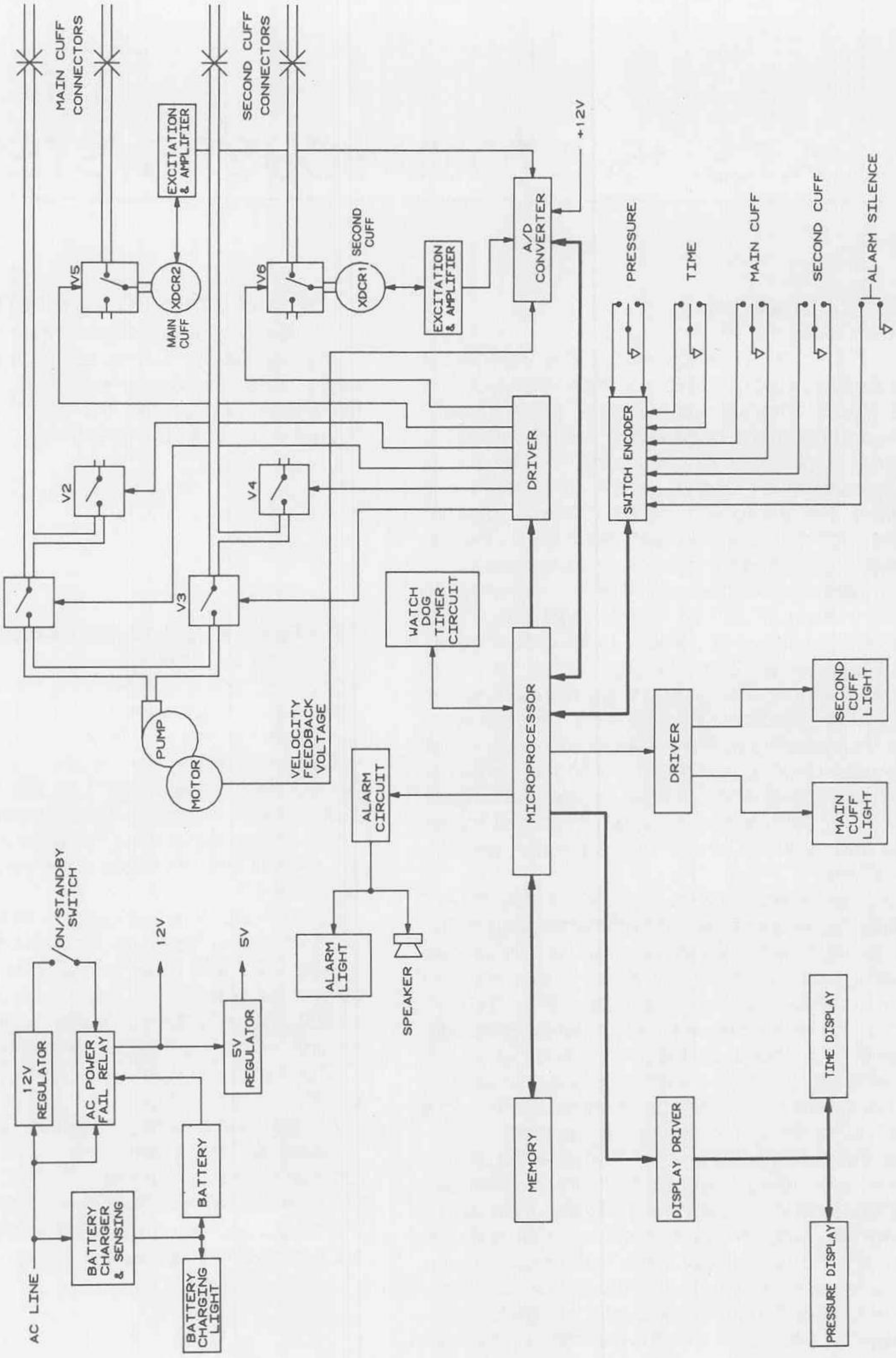
Refer to Figure 4.9

Primary AC power is supplied to the unit via the power cord with fault protection provided by A4F1. A non-resettable thermal fuse is encapsulated between the windings of the power transformer A3T1, and connected between terminals 1 and 2. In the event of a fault condition that would result in winding temperatures which would degrade the insulation of the transformer, the thermal fuse would open removing primary power from the unit.

With a nominal primary voltage, terminals 5 and 6 of the transformer have an output voltage of approximately 17.4 VRMS which is rectified by bridge CR1 and filtered by capacitor C3 to produce approximately +22.2 VDC at TP2. Note that the voltages listed in this section will vary with load conditions. The voltage at TP2 is used as an input to the 12 volt regulator and the battery charging circuit.

An adjustable voltage regulator (VR1) is used to produce an output voltage of +12 VDC at TP1. The resistive divider comprised of R1, R2, and R3 sets the output voltage. Capacitors C1 and C2 insure stability at the output and adjustment pins while CR5 and CR6 are protection diodes for the voltage regulator.

Figure 3.1 Block Diagram


AC LINE
12V REGULATOR
ON/STANDBY SWITCH
BATTERY CHARGER & SENSING
AC POWER FAIL RELAY
12V
BATTERY CHARGING LIGHT
BATTERY
5V REGULATOR
5V
ALARM LIGHT
ALARM CIRCUIT
SPEAKER
PUMP
MOTOR
VELOCITY FEEDBACK VOLTAGE
V1
V2
V3
V4
V5
V6
MAIN CUFF
XDCR2
EXCITATION & AMPLIFIER
MAIN CUFF CONNECTORS
SECOND CUFF CONNECTORS
XDCR1
SECOND CUFF
EXCITATION & AMPLIFIER
WATCH DOG TIMER CIRCUIT
MEMORY
MICROPROCESSOR
DRIVER
A/D CONVERTER
+12V
SWITCH ENCODER
PRESSURE
TIME
MAIN CUFF
SECOND CUFF
ALARM SILENCE
DISPLAY DRIVER
DRIVER
PRESSURE DISPLAY
TIME DISPLAY
MAIN CUFF LIGHT
SECOND CUFF LIGHT

The voltage from TP2 is also used by the battery charging circuit. Integrated circuit U2 implements a battery charger designed specifically for the type of sealed lead acid battery found in the *A.T.S.* 1500 Tourniquet. The voltage from TP2 is fed into the chip at pins 3 and 5. A 22 µP tantalum capacitor (C4) insures stability of the IC. Precision resistor R7 is used to sense the charging current going into the battery. Transistor Q1 is a pass device for controlling the voltage and current applied to the battery. Diode CR9 is a pass diode used to prevent the battery from discharging when AC power is not present as well as for sensing when a battery is receiving a charge. The resistive divider string comprised of R15, R16, R17, R19, and R6 sets the different voltage and current levels used by the circuit. Upon power up the circuit determines if a battery voltage of at least +11.0 VDC is present. If not (a dead battery or no battery present) the circuit does not output any voltage, however a trickle charge of up to 9mA will be supplied from A2U2-11 to attempt to recover a deeply discharged battery. If a battery is sensed, the first charging stage is a bulk charge state where the circuit provides up to 0.5 Amps DC to the battery while sensing the scaled battery voltage through pins 12 and 13 of U2. When the circuit senses that the battery voltage is approximately +14.2 VDC, the second stage is reached. Here the circuit provides the battery with a constant voltage of +14.9 VDC while sensing the current drawn through R7. When the current drops to approximately 50 mA, the circuit enters the third stage which is a float stage. Here the battery is held at its ideal float charging voltage of +13.8 VDC to optimize standby life. A2U1 and associated circuitry are a differential amplifier/comparator circuit used to control the BATTERY CHARGING light depending on the voltage sensed across A2CR9. A2R12 is a common-mode adjustment for the first stage of A2U1; see CALIBRATION Section. A2CR13 provides temperature compensation for the CHARGING light circuit. A2C12 stabilizes the battery charger.

The battery is connected to the charging circuit through fuse F1 which in conjunction with diode CR10 protects the charging circuit from an accidental polarity reversal while connecting the battery. The battery voltage is also fed to terminals 5 and 8 of relay K1 where it is available to power the tourniquet if AC power is lost.

The unit may be operated on battery power alone (power cord disconnected) for at least 15 minutes. A low battery alarm will be generated whenever the battery voltage is less than +11.5 VDC. If the battery voltage goes below +10.5 VDC, reliable operation cannot be insured so the unit goes into a BATTERY FAIL mode when +10.5 VDC is reached. The ability of the battery to accept a charge will be adversely affected by deep discharge and low battery temperature. Battery life is also degraded by continued deep discharge cycles, high temperature storage, and storage in a discharged state. Because the battery provides the power to operate the unit if AC power fails, operation of the unit without a battery is not recommended. It is recommended that the battery be replaced annually.

When AC power is applied to the unit, terminals 7 and 8 of the transformer have approximately 12.0 VRMS present. This voltage is rectified by bridge CR2 and filtered by capacitor C7 to produce a voltage V_{UNREG} at TP3. Resistor R26 is a bleed off resistor to lower the capacitor voltage for safe servicing. At nominal line voltage, V_{UNREG} is approximately +15.1 VDC. This voltage is applied to terminal 7 of relay K1. The AC from terminals 7 and 8 of the transformer is also rectified by diodes CR3 & CR4 and fed to the coil of relay K1. Thus, whenever AC power is present, relay K1 switches and +12 VDC and V_{UNREG} is present at E7 and E6 respectively. When there is no AC power present, the battery voltage (V_{BAT}) is present at E6 and E7. Diode CR7 protects the coil of the relay during power down.

Moving the power switch to the ON position allows the voltages present at E6 and E7 to be connected to E14 and E9 respectively. With AC power present, the +12 voltage is further filtered by C6 and is available to the main logic board via E10. The +12 voltage is also available at terminal 7 and one side of the coil of relay K2. The voltage V_{UNREG} is connected to terminal 10 of K2 and to the voltage regulator VR2. The output of VR2 is preset at +5 VDC which can be measured at TP5 and is available to the main logic board via E16. Capacitors C10 and C11 insure stability and diode CR11 is a protection diode.

When the *A.T.S.* 1500 Tourniquet has completed its self testing and is ready to commence normal operations, relay K2 is switched by bringing VALVENA (E11) low. This allows +12 VDC to be present at E8 (VALVES) and allows V_{UNREG} to be further filtered by R25 and capacitors C8 & C9. This filtered voltage is called VMOTOR. Whenever the unit determines that the pump must operate, the PUMP DRIVE voltage at E18 causes the emitter follower amplifier (Q2, Q3, and associated resistors) to power the DC motor connected to the pump. Resistor A3R1 provides current limiting and resistors R22 & R23 comprise a resistive divider for a feedback voltage (V_{TACH}) used to determine motor speed. Diode CR12 protects the motor drive amplifier from the inductive voltages of the motor. The resistor from A2K2-8 to 12V Ret protects the relay contacts by limiting peak current during the discharge of A2C8, C9. **The pump assembly has three modes of operation: OFF, IDLE, and RUN. During idle state the pump will vibrate (oscillate). This is normal condition for the pump.**

The voltages and signals coming from and going to the A2 power supply board are connected to the A1 main logic board through a wire/cable harness. Figure 4.9 lists the pin numbers of the cable connector that each voltage/signal goes to.

3.2.2 Microprocessor And Memory

The microprocessor (μP) used in the *A.T.S.* 1500 Tourniquet is an 80C31 with external memory. The μP receives bypassed +5 VDC at pin 40. At power up, capacitor C12 and an internal resistor insure a proper reset by causing the voltage at pin 9 to remain high for at least 24 oscillator periods. The unit uses a 3.58 MHz quarts crystal (X2) along with capacitors C9 and C10 to implement the μP oscillator at pins 18 and 19.

The μP has four 8 bit ports which can be configured in different ways for different applications. In the A.T.S. 1500 Tourniquet port 1 (pins 1 through 8) is used to directly control the valves and cuff lights. Port 3 (pins 10 through 17) is used for a variety of inputs and outputs which will be discussed later. Ports 0 and 2 are used to implement a multiplexed address/data bus for outputting addresses and transferring data. The primary purpose of the bus is to input instructions from the program memory EPROM (U15). To do this the μP places the ALE and $\overline{\text{PSEN}}$ lines (pins 30 and 29 respectively) in a logic high state and then places the address on the address/data bus (please see Figure 3.2). The ALE line goes low which causes the lower 8 bits of the address to be latched into an 8 bit latch that is internal to the 87C64 memory chip. The upper 5 bits of the address are present on pins 21 through 25 of the μP and are held there until after the instruction is read in. The μP then returns $\overline{\text{PSEN}}$ to a logic low bringing the output enable line of the EPROM (pin 22 of U15) low. The program instruction is then output on pins 11 through 19 of U15 and is read by the μP one machine state later. The entire process is repeated until a data read or write operation to an external address occurs.

A data read or write from an external address is different from a program memory fetch in several ways. First, the μP does not pulse the ALE or $\overline{\text{PSEN}}$ lines. This is to insure that the EPROM (U15) does not interpret the address as a request for a program instruction. Secondly, every data read or write to an external address causes either the $\overline{\text{RD}}$ line (pin 17) or the $\overline{\text{WR}}$ line (pin 16) of the μP to go low during the time when the data is transferred on the address/data bus (please see Figure 3.2). Thus the μP constantly fetches instructions from the EPROM interrupting the process only when an external read or write is needed.

Pin 10 of the μP is used to output the highest bit of the display address when writing to the display chip. Pin 11 is used as an input for the alarm silence switch. Pin 12 is an interrupt line that senses when the $\overline{\text{WDTFAIL}}$ line goes low. Pin 13 is the output for the pump drive circuitry. Pins 14 and 15 are outputs for the WDT circuit.

3.2.3 Control Line Decoder

The control line decoder is implemented using a 74HC259 addressable latch (U8) and one quarter of AND gate U9. When the μP wants to write to or read from an external address, the address is output on address/data lines AD0 through AD15. The $\overline{\text{PSEN}}$ strobe line is held high. This prevents the EPROM from intrepreting the address as a request for program memory. With $\overline{\text{PSEN}}$ high, and the address available, either the $\overline{\text{RD}}$ or $\overline{\text{WR}}$ line will go low. This causes the address to be latched into U8 by bringing EN (pin 14 of U8) low. The top three bits of the 16 bit address determine which output of U8 will be active and bit 12 of the address acts as the data. Thus outputting an address of B000 Hex (1011 0000 0000 0000 Binary) would cause the top three bits (101) to select output 5 and cause that output to be a logic 1 (high). This address corresponds to the switch latch. The switch latch will use this control signal, in combination with the RD signal, to enable the outputting of its data on the address/data bus.

The data present on the address/data bus is read by the μP which then brings the $\overline{\text{RD}}$ line high again. The end of the external read occurs when the $\overline{\text{PSEN}}$ line goes low as part of a read from the EPROM. Since the $\overline{\text{PSEN}}$ line is connected to pin 15 of the switch latch (U3), the output is cleared. Thus each strobing of a control line lasts for only a portion of a machine cycle. The process for an external write is the same except that the $\overline{\text{WR}}$ line goes low and the address/data bus outputs data from the μP which is latched into an external location using the WR line and the control line signal for that location. Outputting data to the display chip (address 3000 Hex), the A/D channel select (address 7000 Hex), A/D conversion begin (address D000 Hex), and the alarm tone circuit (address 5000 Hex) are all external write operations. Receiving data from the switch latch (address B000 Hex), and the A/D converter (address 9000 Hex) are external read operations.

3.2.4 Sound Generator

The sound generator is used to produce audible tones for various alarm conditions. The frequencies of the tones used by the A.T.S. 1500 Tourniquet are 996 Hz, 488 Hz, and 244 Hz. To generate these and other frequencies a 2 MHz crystal (X1) is driven by an inverter from U11 and R12, R13, C7, and C8. This signal can be measured at TP1. It is divided into five other frequencies by the frequency divider U5. Outputs Q10 (996 Hz) and Q11 (488 Hz) are used for generating their respective alarm tones. Output Q0 (1 MHz) is the clock signal used by the A/D converter (U16). Output Q1 (500 KHz) is the clock signal for the WDT/Sound circuit (U3). Lastly, output Q4 (62.5 KHz) is used by the second frequency divider (U4) as the input clock. This second divider generates 3 output frequencies. Outputs Q9 and Q11 (61 Hz and 15 Hz respectively) are used by the WDT circuit. Output Q7 (244 Hz) is used directly as an alarm tone.

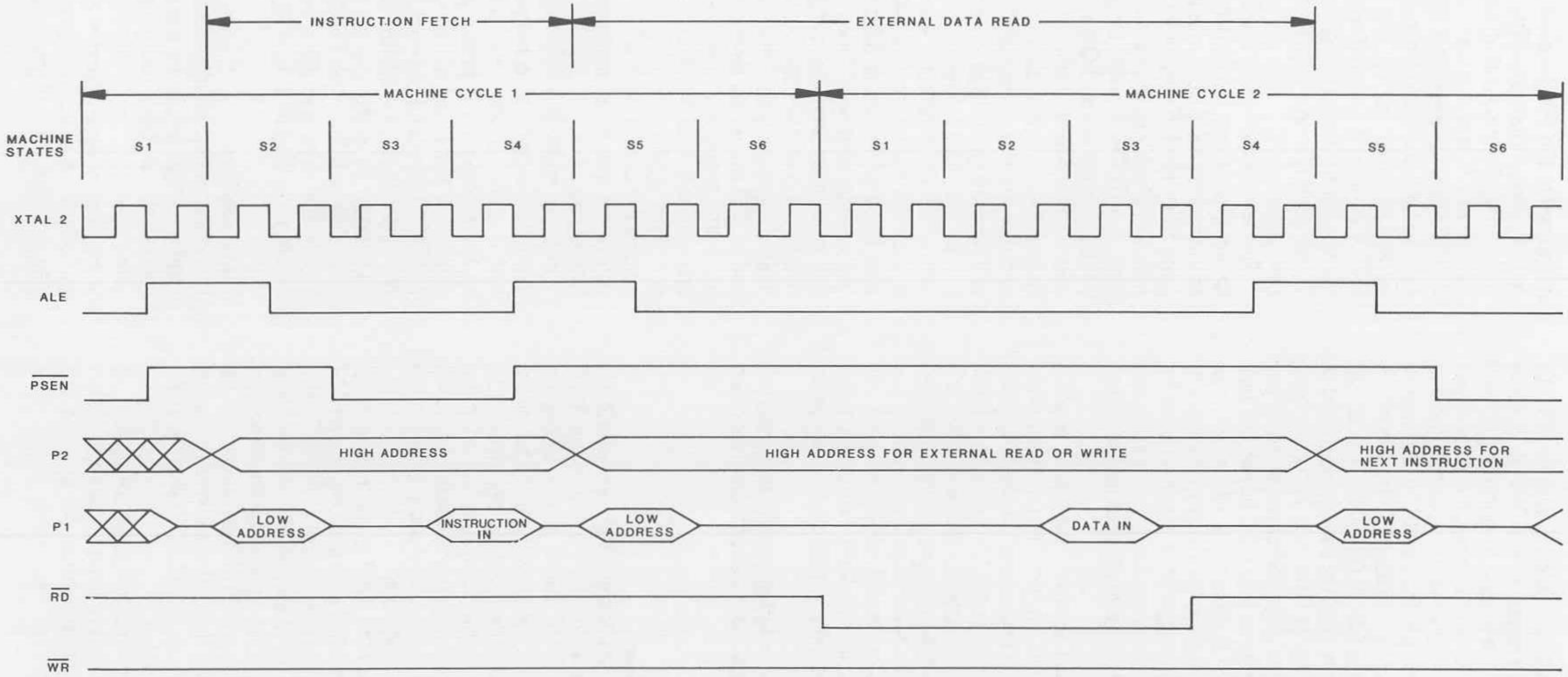

INSTRUCTION FETCH
EXTERNAL DATA READ
MACHINE CYCLE 1
MACHINE CYCLE 2
MACHINE STATES
S1
S2
S3
S4
S5
S6
S1
S2
S3
S4
S5
S6
XTAL 2
ALE
PSEN
P2
HIGH ADDRESS
HIGH ADDRESS FOR EXTERNAL READ OR WRITE
HIGH ADDRESS FOR NEXT INSTRUCTION
P1
LOW ADDRESS
INSTRUCTION IN
LOW ADDRESS
DATA IN
LOW ADDRESS
RD
WR

Figure 3.2 Microprocessor Timing Diagram

The WDT/Sound circuit is implemented in U3, an erasable programmable logic device (EPLD). The circuit receives the three alarm tone frequencies as well as ground and +5 VDC and connects one of these inputs to its output (pin 20 of U3) depending on the address present at pins 16, 17, and 18. The possible outputs are thus ground, +5 VDC, 244 Hz, 488 Hz, & 996 Hz at binary address 000, 001, 010, 011, & 100 respectively. The output (pin 20) is connected to one of the open collector drivers in U1 which in turn is connected to the alarm light and the speaker. Both the alarm light and speaker have +12 VDC applied to their other terminals. When an alarm tone is output, U1 sinks current at the selected frequency causing the tone to be emitted and the alarm light to illuminate. Resistors R3 and R4 limit the power dissipated by the light and speaker while resistor R51 insures proper turn on of the open collector driver.

The WDT/Sound circuit receives the sound address information from U12 a four bit latch. To output an alarm tone, the μP writes the tone information to external location 5000 Hex. This causes the control line decoder to pulse the SOUND line high. This signal is AND'ed with the WR signal from U11 pin 8 and the tone information is latched into U12 from the three least significant bits of the address/data bus. The output of U12 remains constant until another write to it occurs, thus an alarm tone will continue to sound until it is deliberately turned off or changed by the μP.

The +5 VDC output is used to brightly illuminate the alarm silence light to indicate the alarm tone has been temporarily silenced.

3.2.5 Watch Dog Timer

The primary function of the Watch Dog Timer (WDT) is to detect timing errors in the μP (U14). If the WDT detects an error, the $\overline{\text{WDTFAIL}}$ line is latched low which causes the interrupt line at pin 12 of the μP to be pulled low and the valve enable line (ENA) to be latched low removing +12 VDC from the pump and valves. If the cause of the timing error is not too severe, the unit will output a 996 Hz alarm tone and display a help message on the front panel displays.

The basic operation of the WDT is relatively simple. The software has one main loop that is begun every 37 mSec. At the beginning of every loop, a $\overline{\text{WDTSTB}}$ signal emanates from pin 14 of the μP. The WDT is reset by this signal. There is a timing window implemented in the WDT such that if the $\overline{\text{WDTSTB}}$ pulse occurs too soon or too late the WDT fails. The maximum period allowed between pulses is 40 mSEC., and the minimum period is 33 mSEC.

The WDT is implemented in the same EPLD (U3) as the sound circuit. This chip contains decoding logic as well as latched registers. Because the μP and the EPLD use different clocks, the signal is first synchronized to the 500 KHz clock entering U3 at pins 1 and 13 (see Figure 3.3). The $\overline{\text{WDTSTB}}$ pulse is a 3.3 uSec. negative pulse that can be observed at TP2. Capacitor C5 and pull up resistor R10 ensure that the $\overline{\text{WDTSTB}}$ pulse eventually goes high even if the μP were to fail in the middle of outputting the signal. Resistor R14 limits the current going into pin 5 of U11. The $\overline{\text{WDTSTB}}$ pulse is inverted by U11 and is used to reset the frequency divider U4 at the same time it resets U3. Thus all WDT timing relationships begin from one zero point.

The timing window in the EPLD is implemented as follows (please see Figure 3.4): A $\overline{\text{WDTSTB}}$ pulse is synchronized by the EPLD and the internal signal $\overline{\text{STB}}$ is generated. The $\overline{\text{STB}}$ signal is used to reset registers Q1 and Q2 which are internal to the EPLD. At the same time, the $\overline{\text{WDTSTB}}$ pulse resets frequency divider U4 whose outputs Q9 and Q11 are connected to inputs J1 and J2 of the EPLD (Pins 11 and 2). The frequency divider then commences to count and eventually J1 and J2 are present. Signal J2 is ignored by the EPLD until J1 has gone high. When J1 does go high this causes internal register Q1 to go high and stay there until a $\overline{\text{STB}}$ pulse resets it. After Q1 goes high, the next low to high transition of J2 will cause Q2 to latch high also. In part A of Figure 3.4 it is seen that a $\overline{\text{STB}}$ pulse occurs at its normal 37 mSec interval and J1, J2, Q1, & Q2 are all reset. In part B the $\overline{\text{STB}}$ pulse occurs outside of the timing window and both Q1 and Q2 are latched high. This causes the $\overline{\text{WDTFAIL}}$ line to latch low and further $\overline{\text{STB}}$ pulses are ignored. The $\overline{\text{WDTFAIL}}$ line interrupts the processor, the valve enable line (ENA) is brought low, and the WDT cannot be reset without removing power from the unit. Thus a timing error causes the unit to fail in a nonrecoverable safe condition where the valves seal the cuffs off and the pump is disabled.

In order to test the WDT, the EPLD does not implement the permanent latching of the $\overline{\text{WDTFAIL}}$ line until after it senses a logic low at pin 23. Right after power-up, but before enabling the relay with the $\overline{\text{WDTENA}}$ signal, the μP tests the WDT by varying the timing of the $\overline{\text{WDTSTB}}$ line and looking at the $\overline{\text{WDTFAIL}}$ line. If the WDT passes all of the tests, and all other self checks have been sucessfully completed, the μP brings the $\overline{\text{WDTENA}}$ line low. The EPLD then brings the valve enable line high and will react to any timing error by latching the $\overline{\text{WDTFAIL}}$ and ENA lines low.

3.2.6 Displays

The displays (I1 through I4) are common cathode, 14 segment, high efficiency alphanumeric LED displays used to convey data, calibration, and error messages to the operator. I1 and I2 are referred to as the PRESSURE display while I3 and I4 are the TIME display. The cathode drive, supplied to pins 11 and 16 of each display, is about 190 mA per character. The scan rate is

Figure 3.3 $\overline{\text{WDTSTB}}$ Synchronization Timing Diagram

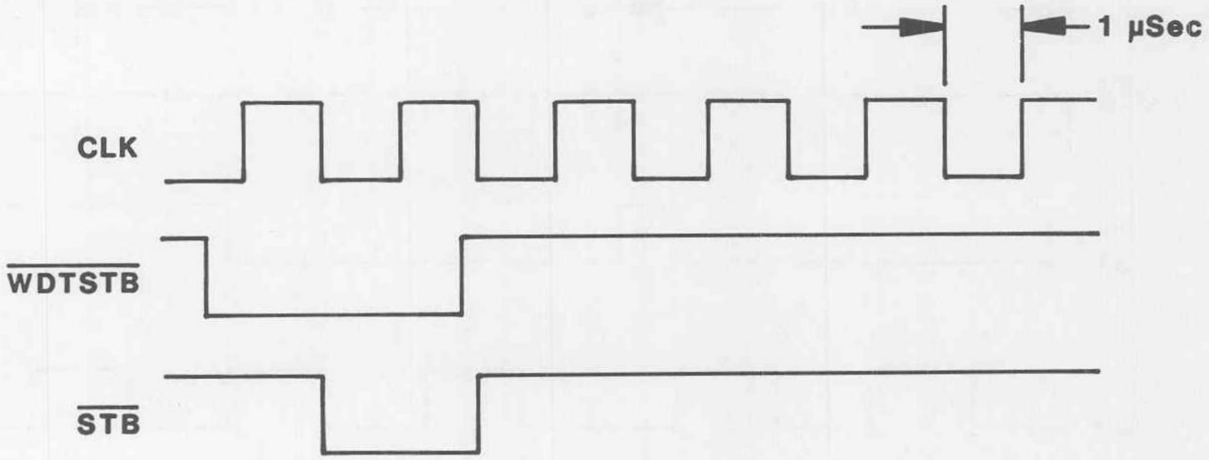
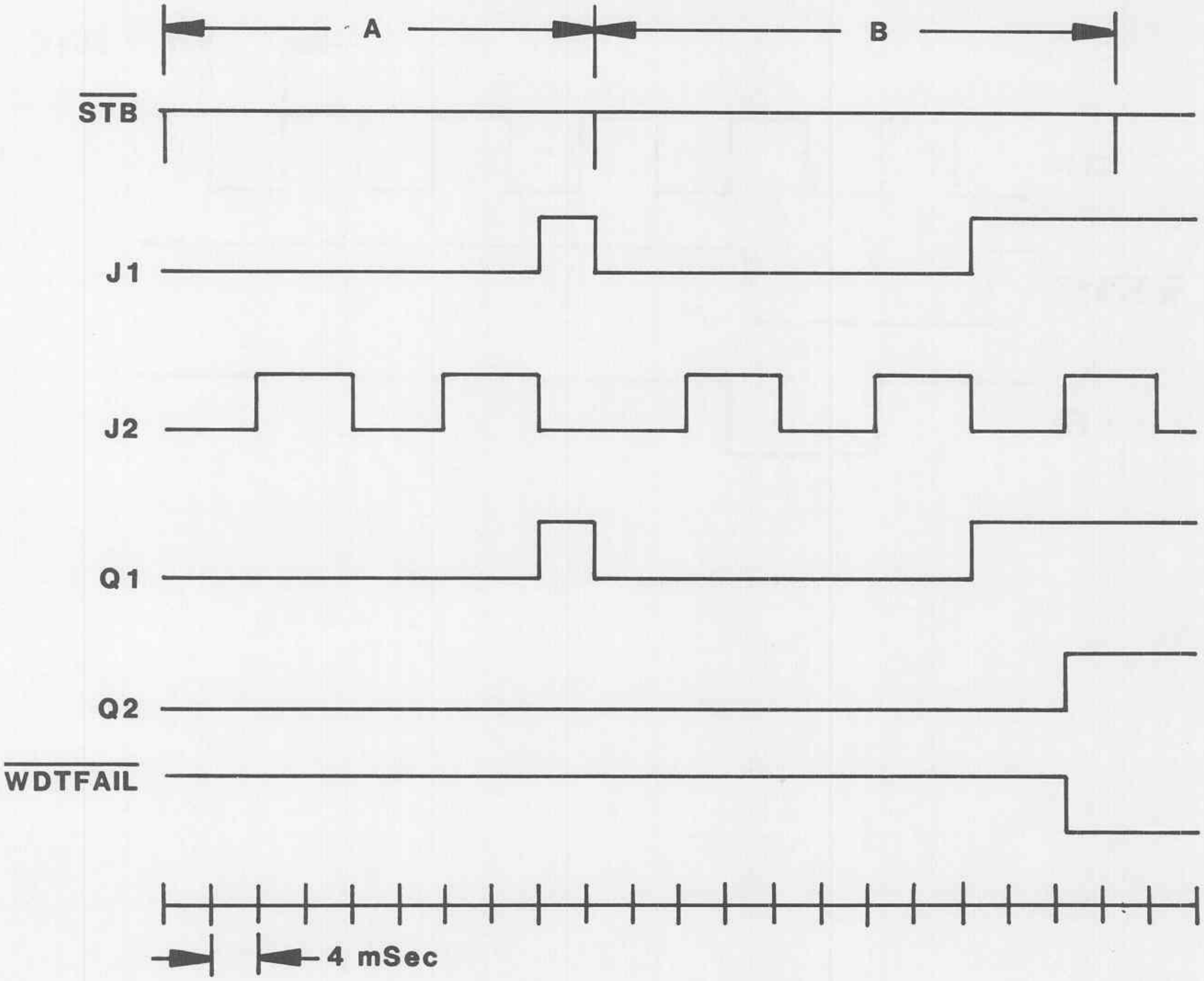

1 µSec
CLK
$\overline{\text{WDTSTB}}$
$\overline{\text{STB}}$

Figure 3.4 WDT Timing Diagram


A
B
$\overline{\text{STB}}$
J1
J2
Q1
Q2
$\overline{\text{WDTFAIL}}$
4 mSec

approximately 400 Hz. The LED driver chip (U13) is a self contained system for storing characters and driving the multiplexed displays. The chips memory holds eight characters and is configured for randomly addressing the desired character by connecting the mode pin (pin 31) to ground. To write to a character, the μP first places the most signinficant bit of the character address on pin 10 (P3.0). The other two address bits become the top bits of the 8 bit word which is output during an external write to the display chip. The lower six bits of data are the code for the character to be displayed. After combining the bits into a word, the μP completes the external write to address 3000 Hex. The control line decoder activates the DISPLAY control line which is NAND'ed with the WR signal to create an active low signal at pin 17 of the display IC. The 8 bit word is latched into the chip along with the high bit of the character address which is connected to pin 28. The display IC will then display the character until new data is written to that character address.

3.2.7 Switches and the Switch Latch

There are nine switches on the *A.T.S.* 1500 Tourniquet.They are all implemented as +5 VDC pull up lines that are grounded when a switch is activated. Resistor network RN5 and resistor R11 provide the current limited +5 VDC. The eight most commonly used switch signals are connected to the switch latch (U6) which is a 74HC573. The switch is periodically read by the μP via an external read from address B000 Hex. The address is decoded by the control line decoder (U8). The resulting SWITCHES signal is NAND'ed with the RD signal from U7 pin 11 to generate the output enable (OE) signal and inverted to generate the ENA signal for the switch latch. The μP then reads the switch data from the address/data bus (AD0 through AD7). The ninth switch line comes from the alarm silence switch and is connected to the μP at pin 11 where its status can be read directly.

3.2.8 Pressure Transducers and Amplifiers

In the *A.T.S.* 1500 Tourniquet cuff pressure is sensed by XDCR1 and XDCR2, double ended silicon diaphragm pressure transducers. The transducers, along with their signal conditioning circuitry, convert sensed pressure into proportional analog voltages which are translated by the A/D converter and used by the μP in the pressure control algorithm.

In the following paragraphs, the operation of the Main Cuff Amplifier will be discussed. Since the amplifiers and excitation circuits for the two cuffs are electrically identical, a detailed description of the second cuff will not be made. Instead, whenever a component or test point is referenced, the corresponding reference designator for the Second Cuff Amplifier will be shown in brackets [ ]. Thus by substituting what you find in brackets, a description of the Second Cuff Amplifier can be obtained.

The transducers are supplied with a set of selected compensation resistors which either reside on the PWB as R201 through R205 [R101 through R105], or are included on a ceramic substrate attached to the bottom of the transducer itself. A transducer and its associated resistors must ALWAYS be replaced as a set. In addition, if the resistors are the discrete types on the PWB, one of the resistors will be a short (piece of wire) and one is always absent. The transducers have a full scale range of 500 mmHg. They have a span of 120 mV and an offset null of −60 mV.

A nominal excitation of 1.5 mA is supplied to the transducer by a constant current source comprised of one half of U21 [U18] and some associated resistors. The gain (span) of the transducer, in mmHg, is adjustable by varying this current excitation via R39 [R20]. With no pressure applied to the transducer, its output is nominally −60 mV ($V_{TP11}-V_{TP12}$) [$V_{TP5}-V_{TP6}$]. The transducer is nulled at a pressure of 247 mmHg.

The output of the pressure transducer is connected to a differential instrumentation amplifier comprised of U20, U22, and the second half of U21 [U17, U19, and the second half of U18]. The gain of U20 [U17] and U22 [U19] are set at 80 by R36/R44 and R47/R48 respectively [R28.R27 and R29.R30]. Capacitors C19 and C20 [C16 and C18] provide single pole, low pass filtering. Offset errors contributed by the transducer and the amplifiers are adjusted out by potentiometer R37 [R19]. This is done with the transducer nulled (247 mmHg applied) during the calibration procedure. The level of the common mode voltage applied to the differential amplifier is also varied during calibration and is adjusted using potentiometer R41 [R21].

The outputs of the amplifier are connected to the inputs of the A/D converter after current and voltage limiting is performed using resistors R45 & R46 [R34 & R35] and diodes CR4 & CR3 [CR2 & CR1] which are connected to a 4.7 volt zener diode (CR5). Thus the voltage at the inputs to the A/D converter cannot rise above 5.3 VDC (4.7V + 0.6V across the signal diode). This voltage limiting protects the A/D converter from damage while the current limiting protects the zener. Resistor R43 biases the zener to insure voltage stability.

With no pressure applied to the transducer, the nominal voltages present at TP14 and TP13 [TP8 and TP10] are approximately 98 mV and 4.902 V respectively. With 247 mmHg applied to the transducer the differential voltage ($V_{TP14}-V_{TP13}$) [$V_{TP8}-V_{TP10}$] is zero.

The *A.T.S.* 1500 Tourniquet achieves an effective 9 bit resolution in sensed pressure readings despite the fact that it uses an 8 bit A/D converter. This patented method is accomplished by lowering the common-mode voltage at the output of the differential amplifier by the equivalent of ¼ bit. This appears as a ¼ bit increase in pressure at TP13 [TP10] and a ¼ bit decrease in pressure at TP14 [TP8]. This is the equivalent of a ½ bit shift in the voltage $V_{TP14}-V_{TP13}$ [$V_{TP8}-V_{TP10}$].The advantage of this method is that the digitized equivalent of the quantity ($V_{TP14}-V_{TP13}$) [$V_{TP8}-V_{TP10}$] changes value when the pressure input changes only ½ bit of the resolution of the 8 bit A/D converter.

3.2.9 A/D Converter

The A/D converter (U16) is an 8 bit, 8 input, CMOS, microprocessor compatible device. The 8 bit address/data bus from the μP is connected to the data port on the device and the 3 least significant bits of the address/data bus (AD0, AD1, AD2) are connected to the three address lines of the converter. The analog voltages from the transducer amplifiers are connected to inputs IN0 through IN3. Input IN4 is connected to the signal V_{TACH} which is a voltage that is proportional to the speed of the pump. Input IN5 is connected to the +12 VDC power line through dividing resistors R23, R22, and potentiometer R26. The voltage measured at IN5 is representative of the +12 VDC supply when AC power is present, and of the battery voltage when AC power is not present. Input IN6 is connected to a signal called VFAIL which is normally near 0 VDC but which rises to about +2.5 VDC when an improper combination of valve/pump activations has occured. The CLK (pin 10) input receives a 1 MHz clock signal from frequency divider U5.

The microprocessor begins a data conversion by first outputting an address to the A/D converter. This address describes the input pin from which U16 takes the signal to digitize. The 3 least significant bits of the data output by the μP becomes the address for U16. Thus 001 would cause the A/D converter to sense input IN1. The μP sends the information to the A/D converter by performing an external write to external address 7000 Hex. The control line decoder pulses the A/D WRITE line which is AND'ed with the WR signal from U11. The resulting signal pulses the ALE line (pin 22) of the converter which latches the data into the address lines of the device. To tell the converter to begin the actual conversion, the μP writes a zero to external address D000 Hex. This causes the control line decoder to pulse the A/D start line connected to pin 6 (START) of the converter. With the 1 MHz clock, the conversion takes approximately 100 uSec. The μP executes a software wait loop while the conversion takes place. To read the result of the conversion, the μP does an external read from location 9000 Hex which causes the control line decoder to pulse the A/D READ line high. When this is AND'ed with the RD signal from U7, the result brings the output enable line of U16 (pin 9) high long enough for the data to be presented on the address/data bus and read by the μP.

3.2.10 Valves and Valve Relay

The six valves in the *A.T.S.* 1500 Tourniquet are driven by open collector drivers connected directly to port 1 of the μP (pins 1 through 6). Resistor network RN4 provides a pull up for each driver to insure it turns on fully and quickly. The SENSE/CALIBRATE VALVES V5 & V6 in Block Diagram Figure 3.1) receive +12V power at all times when the unit is turned on. The other four valves and the pump only have power when the valve relay (K2 on the Power Supply Schematic Figure 4.9) is activated.

During power up, if the μP completes all of its self checks sucessfully, the $\overline{\text{WDTENA}}$ line is brought low. This enables the WDT/Sound circuit (U3) which in turn brings the ENA line high. The ENA signal is used to energize the valve relay. It does this by turning on an open collector driver in U1, the output of which is connected (via a cable harness) to one side of the relay coil. The other side of the coil is connected to +12 VDC. Thus a logic high on the ENA line causes current to flow through the relay coil and the relay to switch. All of the valves now have +12 VDC available and the pump drive circuit has V_{UNREG} available. From then on, any timing error by the μP, or a valve failure signal from U2 will cause the WDT/Sound circuit (U3) to latch in a fail state with the $\overline{\text{WDTFAIL}}$ & ENA lines low. Thus the relay would then be disabled and all of the critical valves & the pump would be without power. The unit would then be in a safe condition where the cuffs are sealed off to prevent pressure loss.

A valve sensing circuit is implemented in EPLD U2 to determine when abnormal combinations of valve/pump actuations occur. The circuit is designed to sense these combinations whether they are due to a software failure or a failure of the valve/pump drivers. The circuit receives its clock signal from a 20 Hz oscillator formed by C6, R15, R16, and two inverters from U11. When the valve relay has been activated by the μP (through U3), the valve sense circuit begins sensing the voltages at pins 2 through 9. When a valve or the pump is off, +12 VDC exists at the point where valve/pump connects to its respective open collector driver. Resistor netwoks RN1, RN2, and RN3 divide the respective voltages down to logic levels where they can be sense by U2. When a valve or the pump is on, the respective voltage sensed by U2 will then be 0 VDC. Any abnormal combination of valve/pump actuations which continue for more than 2 clock cycles (approximztely 100 mSec) causes pin 12 (VFAIL) to go high. This signal is connected to the WDT circuit (U3) and to the A/D converter (U16). The WDT circuit reacts to the VFAIL signal the same as a timing error. The valve relay is disabled and an interrupt signal is sent to the μP ($\overline{\text{WDTFAIL}}$). The μP checks the voltage at pin 6 (VFAIL) of the A/D converter and if a voltage is present it knows the failure was due to a valve problem. It can then place the appropriate message on the displays. With no voltage present, the failure would be due to a WDT failure.

3.3 AUTOZERO

During the power-up diagnostic self-tests, and periodically during operation, the *A.T.S.* 1500 Tourniquet completes an autozero of the pressure transducers and amplifiers. This autozero is performed by connecting a pressure transducer to the atmosphere, allowing the pressure to stabilize, taking a pressure reading, and by reconnecting the transducer to the cuff. The reading taken is considered as zero pressure and is used as an offset in the subsequent measurement of cuff pressure. Periodic autozeroing allows the unit to compensate for amplifier drift. An out of range reading indicates a cuff channel is out of calibration. This may be caused by improper calibration, amplifier drift, or a hardware problem in the amplifier or the valve used to connect the transducer to the atmosphere. If this out of range condition is detected during the power-up self-tests, an immediate CAL FAIL message is displayed and the unit will not operate. During operation, three consecutive out of range measurements are required on an individual cuff before the unit enters a CAL FAIL state. This prevents the unit from entering the CAL FAIL state due to an intermittent valve malfunction or noise in the pressure measuring circuit. During the power-up self-tests, both amplifiers are autozeroed at the same time. Because a simultaneous autozero during operation may cause a disturbance in the regulation of small cuffs, the amplifiers are alternately autozeroed approximately every 76 seconds. Thus if an amplifier were to drift out of range and stay there, the CAL FAIL state would not be entered for up to 456 seconds. If an amplifier output voltage becomes 0 VDC or ≥ +5 VDC due to drift or a hardware failure, the unit enters an AMP FAIL state within 370 mSec.

MAINTENANCE

SECTION 4.0

A.T.S. 1500 TOURNIQUET SYSTEM

4.1 GENERAL MAINTENANCE INFORMATION

While the *A.T.S.*1500 Tourniquet has been designed and manufactured to high industry standards, it is recommended that periodic inspection and calibration be performed to insure continual safe and effective operation. This section contains information intended to assist in that effort as well as serve as a guide to expediting unscheduled maintenance.

The unit is organized into easily accessible modular assemblies for ease of service. The major subassemblies of the unit are shown in Figures 4.1 through 4.6.

4.2 ACCESS TO PARTS

CAUTION: BE SURE THAT THE UNIT IS TURNED OFF AND THE POWER PLUG IS UNPLUGGED BEFORE DISASSEMBLY.

CAUTION: MANY OF THE PARTS ON THE PWB ASSEMBLIES ARE STATIC SENSITIVE. TAKE APPROPRIATE PRECAUTIONS WHEN SERVICING THESE BOARDS.

Access to all internal parts except the A1 PWB is accomplished by removing two screws from each side of the unit and lifting the Front Panel Assembly away from the Rear Panel Assembly. The Front Panel Assembly may be turned over and laid on its face beside the Rear Panel Assembly. Figure 4.6 shows the unit in this configuration.

To gain access to the A1 PWB Assembly:

a) Disconnect the tubing that exits from the two holes in the Valve Cover Assembly. The tubes should be disconnected where they attach to the valve manifold and NOT at the end going through the Valve Cover Assembly or damage to the pressure transducers may occur. To preclude any damage, always use your fingers to connect or disconnect the tubing.

b) Disconnect the tubing at the four cuff connectors.

c) Disconnect the tubing from the overpressure regulator mounted on the rear panel.

d) Disconnect the Valve Cover Wire Harness at the connector on the A1 PWB.

e) Remove the four screws securing the Valve Cover Assembly. The Assembly may now be carefully lifted to expose the A1 PWB.

4.3 PERIODIC MAINTENANCE

Perform the tests and inspections of this section not less frequently than every 6 months.

4.3.1 Cleaning

The exterior of the unit may be cleaned by wiping it with a cloth that has been dampened (not dripping) with a mild detergent. The interior of the unit may be vacuumed or blown out as required. The exterior of the cuff hoses may be cleaned using a mild detergent solution or with alcohol. The interior of the cuff hoses should not be cleaned. Tourniquet cuffs should be cleaned in accordance with their individual instructions.

4.3.2 Inspection

The unit should be inspected at regular intervals. It is recommended that a visual inspection be performed by a qualified technician at least every six months. Points to be included in the inspection are:

- Obvious internal or external damage.
- Condition of the power cord.
- Tightness of the power cord and power cord strain relief.
- Tightness of pneumatic fittings.
- Condition of tubing (both internal and external cuff connection tubing).
- Accumulation of dust or dirt within the unit.
- Mating integrity of internal connectors.
- Integrity of battery fuse mounted on A2 PWB in Rear Panel Assembly.
- Security of the microprocessor (A1U14) and EPROM (A1U15) in their sockets.
- Integrity of the cuff tubing O-Rings and Luer Connectors.
- Tightness of the pump mount.
- Integrity of the pump filter.

4.3.3 Functional and Calibration Checks

In addition to the internal calibration check that the unit performs during each power-up sequence, and the other periodic maintenance steps outlined by this section, it is recommended that the Functional and Calibration Checks described in section 2.2 be performed on at least a quarterly basis.

4.3.4 Calibration

Calibration of the *A.T.S.*1500 Tourniquet consists of a series of tests during which adjustments to the signal conditioning circuitry of the pressure transducers are made. These adjustments are made by inserting an adjustment tool through the holes above the cuff connectors at the front of the unit.

The unit's software contains an instruction set for the Calibration Mode that is independent of the normal operating software. Within the Calibration Mode, individual subroutines may be called to perform specific calibration tasks. These subroutines are entered by appropriate operation of the unit's touch-switches. The functions of each of these switches are described in Table 4.1. The Calibration Mode is entered by depressing the TIME DECREASE and PRESSURE DECREASE touch-switches while the ON/STANDBY switch is set to the ON position. After the unit is on, the touch-switches are released and the words CAL MODE appear on the displays. It is recommended that the unit remain in this mode for at least ten minutes to allow the components to reach operating temperature. To return to normal operation after calibration, momentarily set the ON/STANDBY switch to STANDBY.

Once in the Calibration mode, the PRESSURE INCREASE touch-switch may be used to select the amplifier that you wish to calibrate. The amplifier currently being calibrated is indicated by the illumination of the appropriate CUFF light and by the message displayed on the front of the unit. The unit defaults to calibrating the main cuff amplifier first. After the calibration sequence has been completed (sections 4.3.4.1 through 4.3.4.4) the PRESSURE INCREASE touch-switch should be pressed to change to the second cuff amplifier and the sequence repeated.

RECOMMENDED CALIBRATION INTERVAL: Every 6 months. Calibration should also be performed after any unscheduled maintenance and in the event that the unit fails self-test.

EQUIPMENT REQUIRED:

1. Manometer or other calibrated pressure measuring instrument capable of measuring at least 300 mmHg.
2. Calibration Kit, Zimmer Catalog No. 60-1468-003

NOTE: Since the calibration adjustments are interactive to some extent, calibration should be performed in the sequence shown to minimize reiteration.

4.3.4.1 Transducer Offset

A. Using the Internal Pressure Source

1) Connect a 0-300 mmHg manometer to the cuff output of the amplifier under test using the "T" hose assembly (See Figure 4.7) of the Calibration Kit. Verify that the valve of the "T" hose assembly is fully closed. NOTE: In addition to the manometer, there must be a cuff or other volume attached to the "T" hose assembly to insure the tourniquet will operate properly.
2) Connect the power cord to an appropriate power receptacle.
3) Enter the Calibration Mode.
4) Verify that the PRESSURE display reads CAL and the TIME display reads MODE. It is recommended that the unit warm up in this mode for at least ten minutes to allow the components to reach operating temperature.
5) Press and hold the TIME DECREASE touch-switch and verify:
   a) The PRESSURE display reads OFST.
   b) The TIME display indicates the designator of the potentiometer that should be adjusted for this portion of the calibration sequence. (R37 for the main cuff amplifier and R19 for the second cuff amplifier). These designators match the ones that appear beneath the adjustment holes in the output panel at the bottom front of the unit.
   c) Release the touch-switch. The pump should begin to run.
   d) After the pump has stopped, verify that the TIME display reads 247 and the PRESSURE display indicates sensed pressure as verified by the manometer.
6) Using the adjustment tool provided in the calibration kit, adjust the previously indicated potentiometer until the PRESSURE display and manometer are in agreement (within 1mmHg). Allow about 10 seconds of settling time between

Figure 4.1 A1 Logic PWB Assembly

Assembly Number	**61-3404-001**
Replacement Part Number (less U15, U2, U3, & hose)	**62-9000-001**

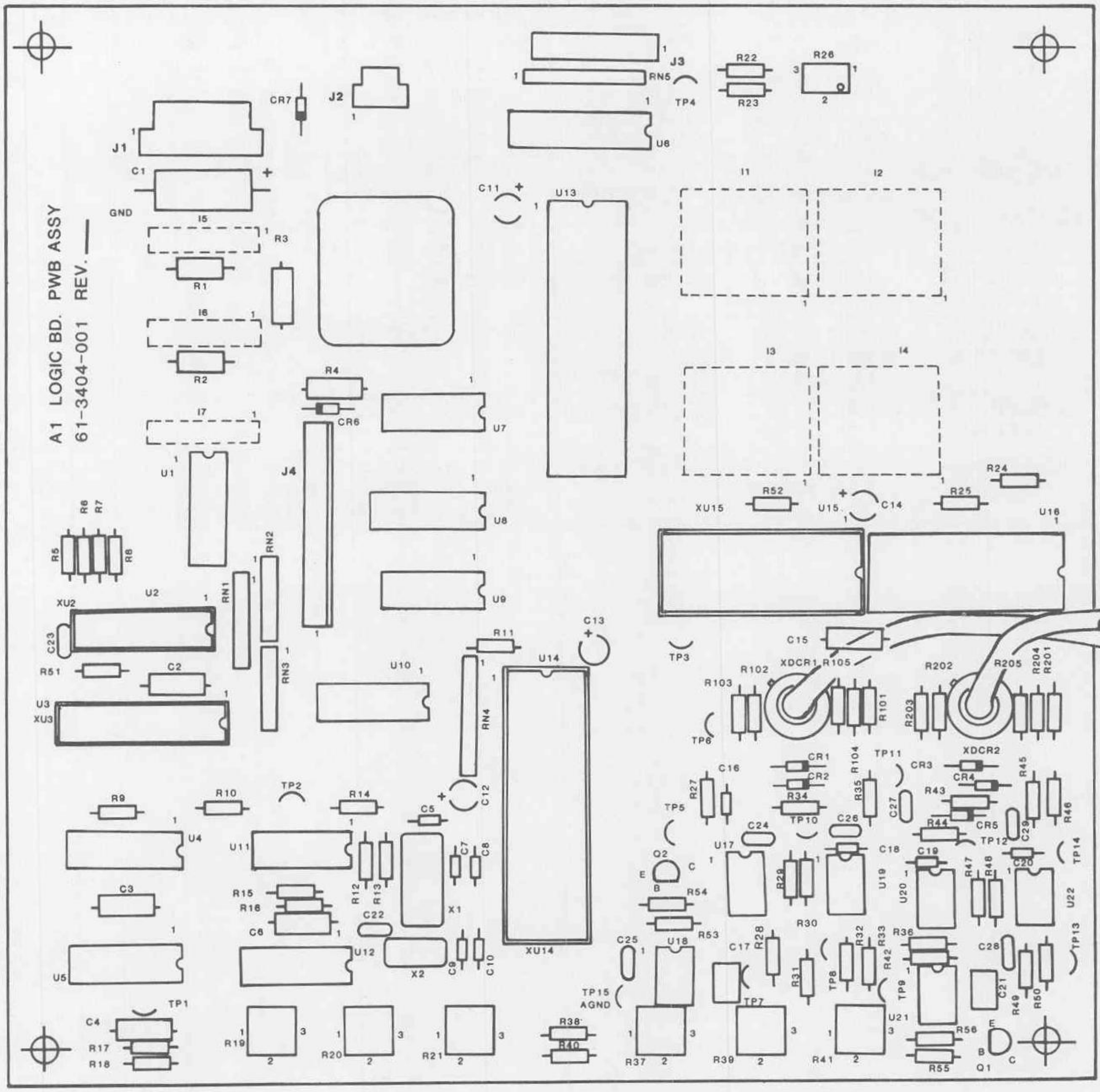
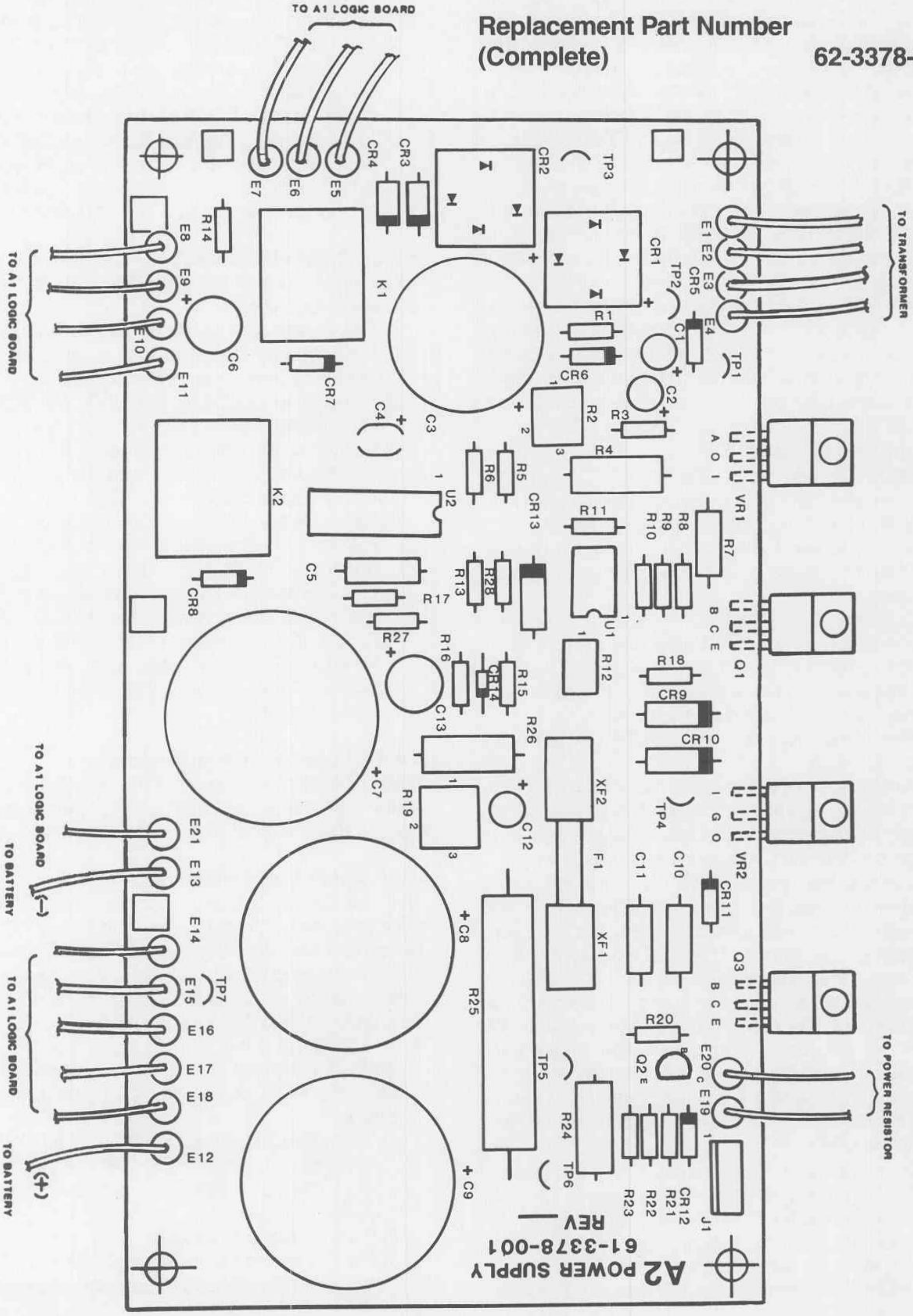

A1 LOGIC BD. PWB ASSY
61-3404-001 REV. ___
J1
J2
J3
J4
CR7
RN5
R22
R23
R26
TP4
U6
C1
GND
I5
R3
R1
I6
R2
I7
R4
CR6
U7
C11
U13
I1
I2
I3
I4
U1
R6
R7
R5
R8
RN1
RN2
RN3
U2
XU2
C23
R51
C2
U3
XU3
U8
U9
R11
U10
U14
C13
TP3
XU15
R52
U15
C14
R25
R24
U16
C15
XDCR1
R105
R102
R103
R101
R202
R205
R204
R201
R203
TP6
RN4
XDCR2
R9
R10
TP2
R14
C12
C5
U4
U11
R12
R13
C7
C8
X1
R15
R16
C6
C22
C3
U5
U12
X2
C9
C10
XU14
TP1
C4
R17
R18
R19
R20
R21
R38
R40
R37
R39
R41
C16
R27
TP5
Q2
C24
U17
CR1
CR2
R34
TP10
R104
R35
TP11
C27
C26
C18
R29
R30
U19
U20
CR3
CR4
R43
R44
CR5
TP12
C29
R45
R46
C19
C20
R47
R48
U22
TP14
R54
R53
C25
U18
TP15
AGND
R28
C17
TP7
R31
TP8
R32
R33
R42
R36
TP9
U21
C28
C21
R49
R50
R56
R55
Q1
E
B
C

Table 4.1 Switch Functions & Display Indications in the Calibration Mode

Switch Action	Pressure Display	Time Display	Calibration Mode
NONE	CAL	MODE	Waiting for a command. No specific subroutine entered. Present in this mode upon entering calibration mode or whenever PRESSURE INCREASE touch-switch is pressed.
PRESSURE INCREASE	CAL	MODE	Selects cuff amplifier to be calibrated. Amplifier selected is indicated on the CUFF lights.
PRESSURE DECREASE	R41 or R21 then value between 120 & 140	CMOD then value between 120 & 140	Transducer Common-Mode adjustment.
TIME INCREASE	OFST then sensed pressure	EXTM or EXT2 then R37 or R19	Transducer Offset adjustment using an external precision pressure source.
TIME DECREASE	OFST then sensed pressure	R37 or R19 then 247	Transducer Offset adjustment using the pump as the pressure source.
MAIN CUFF INFLATE	BURN then sensed pressure	IN then BURN	Factory test.
MAIN CUFF DEFLATE	MAIN or 2ND then sensed pressure	SPAN then R39 or R20	Transducer Span adjustment.
SECOND CUFF INFLATE	WDT	SLOW then FAIL	Watch Dog Timer test.
SECOND CUFF DEFLATE	BAT then power supply voltage	VOLT then BAT	Displays the voltage of the +12 VDC power supply when AC power is present, and the voltage of the Backup Battery when AC power is not present.

Figure 4.2 A2 Power Supply PWB Assembly

Assembly Number	**61-3378-001**
Replacement Part Number (Complete)	**62-3378-001**


TO A1 LOGIC BOARD
TO TRANSFORMER
TO A1 LOGIC BOARD
TO A1 LOGIC BOARD
TO BATTERY
(–)
TO A1 LOGIC BOARD
TO BATTERY
(+)
TO POWER RESISTOR
E1 E2 E3 E4
E5 E6 E7
E8 E9 E10 E11
E12 E13 E14 E15 E16 E17 E18 E19 E20 E21
TP1 TP2 TP3 TP4 TP5 TP6 TP7
CR1 CR2 CR3 CR4 CR5 CR6 CR7 CR8 CR9 CR10 CR11 CR12 CR13 CR14
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25 R26 R27 R28
K1 K2
U1 U2
VR1 A O I
VR2 I G O
Q1 B C E
Q2 B C E
Q3 B C E
XF1 XF2 F1
J1
A2 POWER SUPPLY
61-3378-001
REV

successive adjustments.

B. Using an External Pressure Source

This is an alternate method to 4.3.4.1A above. This more accurate method is used during factory calibration and is recommended if the equipment is available. The equipment required is a precision pressure source capable of maintaining 247 mmHg. This mode may be entered by pressing the TIME INCREASE touch-switch. While the touch-switch is held the PRESSURE display shoud read OFST and the TIME display should read either EXTM or EXT2 for calibrating the main or second cuff amplifiers respectively. When the touch-switch is released, the PRESSURE DISPLAY should display the sensed pressure and the TIME display should display the designator of the potentiometer to adjust for that amplifier (R37 for the main cuff and R19 for the second cuff). The precision external pressure source should be adjusted to output 247 mmHg and the indicated potentiometer adjusted so that the pressure display reads 247. Please consult the factory on equipment requirements.

4.3.4.2 Common Mode

CAUTION: The voltages at TP8, TP10, TP13, and TP14 should be kept lower than +5 VDC. A circuit has been included in the design of the unit to protect the A/D converter, however if R21 or R41 are ever replaced, they should be preset to their midpoint before power is applied.

1) Connect a manometer, cuff, or accumulator to the connectors of the cuff under test using the "T" hose assembly from the calibration kit.
2) If not already in the calibration mode, enter it using the instructions found in section 4.3.4.
3) Press and hold the PRESSURE DECREASE touch-switch.
4) Verify that the TIME display reads CMOD (Common MODe), and the PRESSURE display shows the designator of the potentiometer to adjust (R41 for the main cuff and R21 for the second cuff).
5. Release the touch-switch. The unit will pump when the sensed pressure is less than 200 mmHg, and will turn off when the pressure reaches 260 mmHg. The TIME display will show a numerical value in the range of 100 to 130 that is proportional to the voltage on one side of the amplifier (TP14 of the main cuff amplifier and TP8 of the second cuff amplifier. The PRESSURE display will show a value, in the same range, that is proportional to the voltage on the other side of the amplifier (TP13 of the main cuff and TP10 of the second cuff).
6) Using the leak control valve of the "T" hose assembly, create a small leak in the system. This will cause the readings on both displays to fall slowly.
7) Adjust the previously indicated potentiometer such that, while the pump is not running, the TIME and PRESSURE readings are the same (R41 for the main cuff and R21 for the second cuff). NOTE: This is not the final setting.
8) Closely observe the displays while adjusting the potentiometer until the TIME display appears to "lead" the PRESSURE display by 50%. That is, as the pressure falls slowly, the number shown in the TIME display is one less than that in the PRESSURE display 50% of the time. Refer to Figure 4.8 for a graphic representation of this display sequence with the potentiometer properly adjusted. It may be necessary to adjust the leak control valve to facilitate this adjustment.

4.3.4.3 Span Adjustment

This adjustment sets the sensitivity (gain) of the transducer and amplifier.

1) Disconnect all hoses from the cuff connectors.
2) If not already in the calibration mode, enter it using the instructions found in section 4.3.4.
3) Press and hold the MAIN CUFF DEFLATE touch-switch.
4) Verify that the TIME display reads SPAN and the PRESSURE display indicates the cuff amplifier being adjusted (MAIN or 2ND).
5) Release the touch-switch. Observe that the PRESSURE display will show sensed pressure and the TIME display will show the designator of the potentiometer that should be adjusted (R39 for the main cuff and R20 for the second cuff).
6) Adjust the indicated potentiometer until the PRESSURE display reads 0 at about midway between those positions that cause readings of 1 and −1 mmHg.

4.3.4.4 Iteration of Adjustments

Due to the interactive nature of the adjustments, repeat steps 4.3.4.1 through 4.3.4.3 until all steps are within specifications without making further adjustments.

4.3.5 Watch Dog Timer Test

This test causes the timing signal emitted from the microprocessor to change from the normal 37 mSec period to a slow 43 mSec period. The WDT considers this timing period to be abnormal and causes the WDT failure. Please see Section 3.2.5 of this manual for a description of how the WDT works.

A. The following is the test sequence that is normally done to test the WDT. This sequence should follow the completion of sections 4.3.4.1 through 4.3.4.4 above.
   1) Press and hold the SECOND CUFF INFLATE touch-switch. The PRESSURE display should read WDT and the TIME display should read SLOW.
   2) Release the touch-switch.
   3) The unit should immediately go into a WDT failure mode with the PRESSURE display showing WDT

and the TIME display showing FAIL. There should be a high pitch tone emitted and you should not be able to silence it.

4) The ON/STANDBY switch must be moved to STANDBY to leave this mode.

5) If the unit acted as described above the WDT operated correctly.

B. This test may be done when a physical measurement of the WDT signals is desired. It is not as thorough a test as part A above and should always be followed by completion of part A.

1) Begin with the unit turned off.

2) Enter the calibration mode as described in Section 4.3.4.

3) Press and hold the SECOND CUFF INFLATE touch-switch. The PRESSURE display should read WDT and the TIME display should read SLOW.

4) Release the touch-switch.

5) The TIME display reading should change to show 43MS (meaning 43 mSec).

6) The period between the $\overline{\text{WDTSTB}}$ pulses, as measured at TP2, should now be 43 mSec.

7) This mode may be exited by either pressing another touch-switch to get into another calibration mode, or by moving the ON/STANDBY switch to STANDBY.

4.3.6 Leak Testing

The *A.T.S.* 1500 Tourniquet is capable of keeping a cuff with a substantial leak inflated. Naturally it is desirable to keep plumbing leaks to an absolute minimum. For this reason, a check for significant leakage is recommended at regular intervals as well as following any service procedure.

After verification of the operation of the *A.T.S.* 1500 Tourniquet per Section 2.2 of this manual, connect both pairs of cuff connectors to a 24" or larger cuff or equivalent volume accumulator. Set the desired pressure to 475 mmHg. Ensure that all external connections are tight. Inflate the main cuff and allow the pressure to stabilize. Now move the ON/STANDBY switch to the STANDBY position. After 10 minutes, move the switch back to the On position. Operation will resume under Cuff Inflated Start-Up conditions (See Section 2.5 part 3 for a description). Cancel the alarm using the ALARM SILENCE pushbutton. Activate either PRESSURE touch-switch for one second and view the current pressure setpoint. This value should be at least 400 mmHg or more. Values less than this indicate an unacceptable leak rate, and the source of the leak should be traced and corrected. The first connection to check should be the Luer connectors of the cuffs. Different cuffs and/or cuff hoses may be tried to determine if the leak is internal or external to the unit. Repeat same procedures for second cuff.

4.3.7 Power Supply/ Battery Charger

A. Power Supply Adjustments

With the unit plugged in and the ON/STANDBY switch set to ON, the voltage measured at TP1 should be +12 VDC ± 0.1 VDC. This voltage may be adjusted if necessary via potentiometer R2 located on the A2 Power Supply PWB (See Figure 4.2 for location).

NOTE: Ground may be found at TP7 on the A2 PWB.

The output of the +5 VDC voltage regulator is fixed and may be measured at TP5. If the measured voltage is greater than +5.1 VDC or less than +4.9 VDC then the voltage regulator should be replaced.

B. Battery Charger Adjustments

In order to properly adjust the battery charger voltage, the unit must have been plugged in and charging (BATTERY CHARGING light on front panel illuminated) for at least 24 hours. The battery charging voltage is measured at TP4 and should be +13.8 VDC ± 0.1 VDC.

1) Remove A2F1 and verify that the battery leads are connected to the battery. Connect the power cord to an appropriate AC source.

2) Observing the polarity of the capacitor, connect a Battery Simulator (BS), a 22K 1/4W resistor in parallel with a 100 μF capacitor, to A2TP7 (–) and A2TP4 (+).

3) Adjust A2R19 for a voltage across the BS of 13.80 +/– 0.02 VDC.

4) Measure the voltage across A2CR9 with the positive lead of the BS disconnected from TP4. Adjust A2R12 to set the voltage measured from A2U1-1 to TP7 to within 1mv of the voltage measured across A2CR9. The voltage should be 30 to 70 mVDC. Reconnect the positive lead of the BS to TP4, the CHARGING light should come on within a few seconds.

5) Again, disconnect the positive lead of the BS, the CHARGING light should go off.

6) Disconnect the BS completely, reinstall A2F1, the CHARGING light should come on. It may subsequently go off for up to 2 minutes depending on the condition of the battery. The light will go off when the charger changes state.

7) Seal A2R12 and A2R19 with glyptol or the like.

NOTE: The battery charging network is temperature compensated and will change the battery output voltage at approximately –23mV/°C. This can cause the output voltage to appear unstable when in fact it is just following temperature changes.

4.3.8 Battery Voltage and Battery Service

NOTE: This section assumes that the unit has been plugged in and the battery charging for at least 24 hours. When servicing other parts of the unit, it is a good practice to disconnect the connector at the positive (red) terminal of the battery. This will preclude unnecessary battery discharge and other unintended results if the Power Switch is inadvertantly set to ON.

A. Battery Voltage Check

The battery voltage may be measured without opening the unit by following the instructions below. An acceptable battery voltage does not guarantee that the battery has sufficient capacity to maintain normal operation. Only use under battery power can indicate a specific tourniquet's ability to maintain operation during loss of AC power.

1) If not already in the calibration mode, enter it using the instructions found in section 4.3.4.
2) Press and hold the SECOND CUFF DEFLATE touch-switch.
3) Verify that the PRESSURE display reads BAT and the TIME display reads VOLT.
4) Release the touch-switch. The PRESSURE display will still read BAT. The TIME display will show the voltage of the +12 VDC power supply. This voltage should be +12 VDC ± 0.1 VDC. If the +12 VDC supply voltage has been properly adjusted per Section 4.3.7 above, the voltage showing on the PRESSURE supply can be adjusted via potentiometer R26 on the A1 Logic PWB (see Figure 4.1 for location) so that the display and the voltage measured at TP1 of the A2 PWB agree.
5) Unplug the unit. The TIME display will now show the actual battery voltage. This voltage should be in the range of +12.3 VDC to +13.0 VDC. If, after one minute of idling in this mode, the voltage reads less than +12.0 VDC, the integrity of the battery should be suspect and it should be replaced.
6) Plug the unit back in.

B. Battery Service

The +12 VDC sealed lead acid battery is charged by a three stage charging circuit (described in Section 3.2.1) that operates whenever the unit is plugged in. The unit can be plugged in indefinitely without overcharging, provided that the charger voltage has been properly adjusted (see Section 4.3.7B). No maintenance is required of the battery other than charging.

The life of the battery depends on the type of service and the storage method. Battery replacement will need to be more frequent with continued cycles of deep discharge and/or storage in a high temperature environment. Infrequent short-term use of the battery and storage in a room temperature environment will result in maximum life. It is recommended that the battery in the *A.T.S.* 1500 be replaced annually.

4.3.9 Overpressure Regulator

Mounted on the rear panel assembly is the Overpressure Regulator which serves as a redundant pressure monitoring device to limit maximum pressure deliverable by the unit in the event that all other safeguards and pump control mechanisms fail. The unit is designed to regulate cuff pressure up to a maximum of 475 mmHg. The Overpressure Regulator is set to relieve at 550 mmHg ± 25 mmHg to provide an adequate margin above the maximum design pressure. Since the setting of the regulator is somewhat affected by altitude, the user may wish to check its calibration prior to use. This procedure should also be followed if the regulator is ever replaced.

1) With the unit open, enter the calibration mode as described in Section 4.3.4.
2) Disconnect from the regulator the hose that connects it to the Valve manifold.
3) Connect a 0 to 650 mmHg manometer or pressure gauge to the regulator hose barb uncovered in step 2 above.
4) Press the PRESSURE DECREASE touch-switch. The pump will begin to run.
5) Observe the pressure measured by the manometer or gauge. The pressure should stabilize at 550 mmHg ± 25 mmHg. If it does not, adjust the Overpressure Regulator, using the hex adjustment screw at the top, until the correct value is obtained. Test the final setting three times by disconnecting and reconnecting the hose to the manometer/gauge. This insures repeatability. Seal the adjustment screw with Glyptol or equivalent when done.
6) Turn the unit off and reassemble.

4.4 UNSCHEDULED MAINTENANCE

The *A.T.S.* 1500 Tourniquet is designed with several specific self-test features to assist in fault isolation. These features are designed to show a message in the PRESSURE and TIME displays. The meanings of these messages are delineated in Tables 2.1 and 2.2.

Another particular mode of failure that might occur is one where a high pitched tone occurs that cannot be silenced by the ALARM SILENCE pushbutton. The valves and pump will be disabled, and the cuffs sealed off to prevent leaks. The displays may show random characters. If this occurs, the Watch Dog Timer circuit has detected a problem. The microprocessor is not

Table 4.2 Expected Test Point Readings

A1 PWB Test Point	Nominal Reading	Tolerance	Conditions/Comments
TP1	2 MHz Square Wave	± 2 KHz	Master Oscillator for WDT/Sound circuit.
TP2	3.3 μSec Negative Logic Pulse with 37 mSec Period	± 2.5 μSec on period	$\overline{\text{WDTSTB}}$ Signal.
TP3	0.56 μSec Positive Logic Pulse with 1.68 μSec Period	N/A	ALE Signal. Changes period when external read or write occurs.
TP4	+12.0 VDC	± 0.1 VDC	Used to determine the voltage of the +12V/Battery Supply.
TP5	≈ 2.0-4.5VDC	N/A	After proper calibration with 0 mmHg sensed pressure. (Non-critical TP)
TP6	≈ 2.0-4.5VDC	N/A	After proper calibration with 0 mmHg sensed pressure. (Non-critical TP)
TP7	+0.31 VDC	±90 mVDC	Subject to SPAN adjust. Values are after calibration.
TP8	+97.7 mVDC	±58.6 mVDC	After proper calibration with 0 mmHg sensed pressure.
TP9	+0.31 VDC	±90 mVDC	Subject to SPAN adjust. Values are after calibration.
TP10	+4.907 VDC	± 90 mVDC	After proper calibration with 0 mmHg sensed pressure.
TP11	≈ 2.0-4.5VDC	N/A	After proper calibration with 0 mmHg sensed pressure. (Non-critical TP)
TP12	≈ 2.0-4.5VDC	N/A	After proper calibration with 0 mmHg sensed pressure. (Non-critical TP)
TP13	+4.907 VDC	± 90 mVDC	After proper calibration with 0 mmHg sensed pressure.
TP14	+97.7 mVDC	±58.6 mVDC	After proper calibration with 0 mmHg sensed pressure.
TP15	+0.0 VDC	N/A	Ground.

A2 PWB Test Point	Nominal Reading	Tolerance	Conditions/Comments
TP1	+12.0 VDC	± 0.1 VDC	Output of +12 VDC Voltage Regulator.
TP2	+22.2 VDC	± 1.8 VDC	Rectified and filtered output of terminals 5 & 6 of transformer.
TP3	+15.6 VDC	± 1.8 VDC	Rectified and filtered output of terminals 7 & 8 of transformer.
TP4	+13.8 VDC	± 0.1 VDC	Output of Battery charging circuit. Measured with fully charged battery.
TP5	+5.0 VDC	± 0.1 VDC	Output of +5 VDC Voltage Regulator.
TP6	+15.6 VDC	± 1.8 VDC	Measured with pump off.
TP7	+0.0 VDC	N/A	Ground.

NOTES:
1. All measurements made relative to ground.
2. All measurements must be made with the unit connected to AC power with nominal line voltage present.

Figure 4.3 Rear Panel Assembly

Assembly Number	61-3433-001
Power Supply PWB	61-3378-001
Battery	62-3428-001
Pump Assembly	60-7000-008
Resistor 1 ohm/25 W	62-1688-002
Transformer 100/120V	62-3411-001
Transformer 220/240/270V	62-4476-001
Overpressure Regulator	62-3302-001
Wire Harness Assembly	60-7000-011
Speaker	62-0333-001

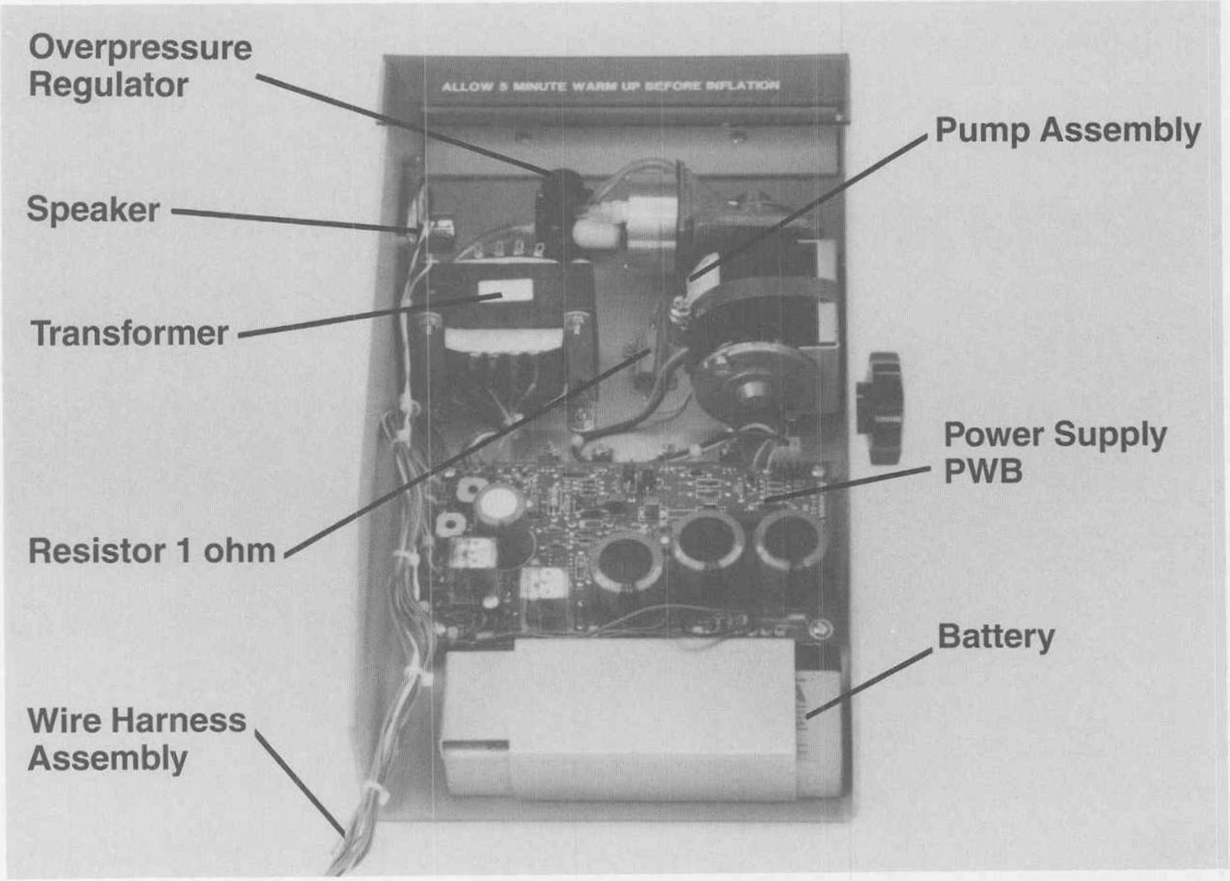

Overpressure Regulator
ALLOW 5 MINUTE WARM UP BEFORE INFLATION
Pump Assembly
Speaker
Transformer
Power Supply PWB
Resistor 1 ohm
Battery
Wire Harness Assembly

Figure 4.4 Front Panel Assembly

Assembly Number	61-3414-001
Logic PWB Assembly	61-3404-001
Cover Panel Assembly	61-3433-001
On/Standby Switch	62-2421-001
Pneumatic Coupling	62-2671-001
Touch Switch Panel	62-3285-001
Output Panel	62-3312-001
Power Cord Assembly	60-7000-013

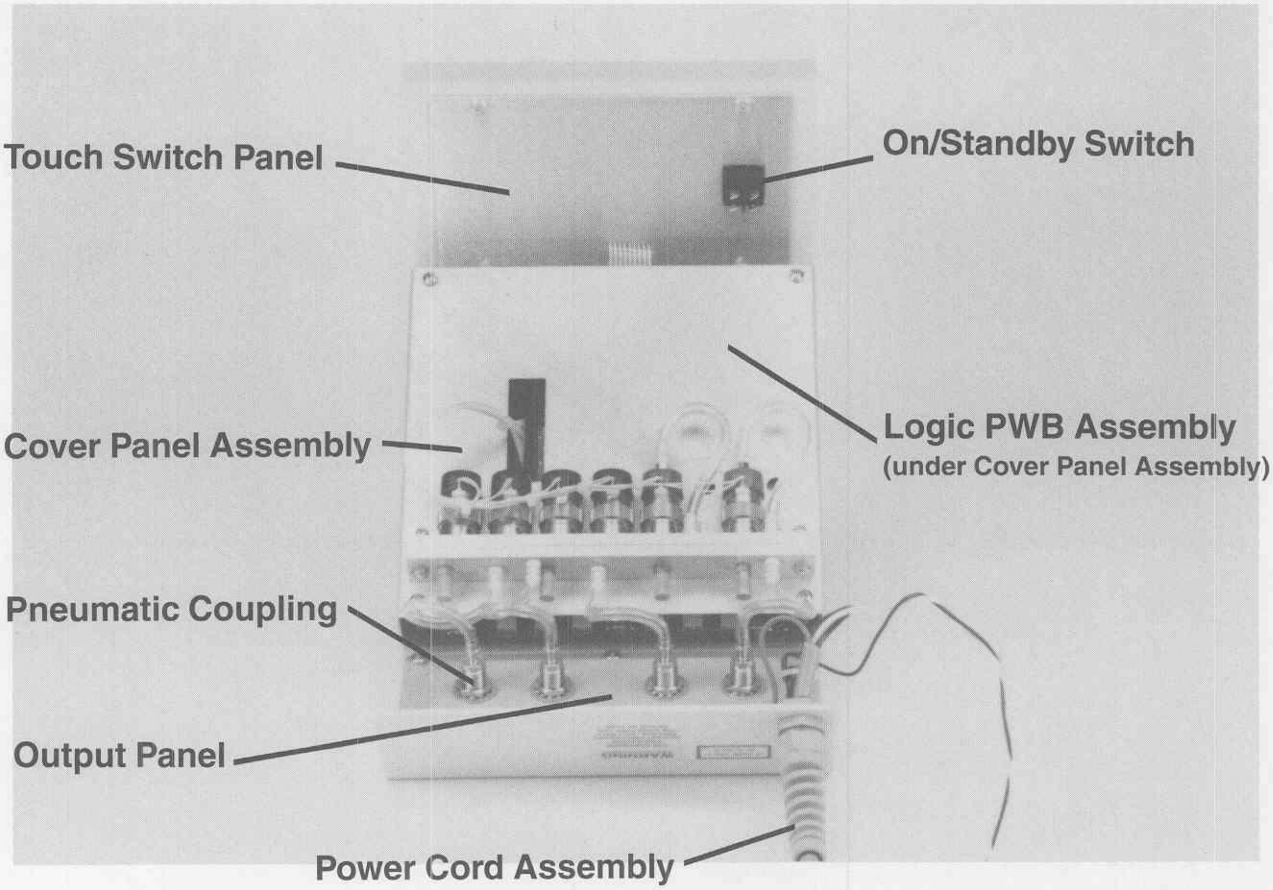

Touch Switch Panel
On/Standby Switch
Logic PWB Assembly
(under Cover Panel Assembly)
Cover Panel Assembly
Pneumatic Coupling
Output Panel
Power Cord Assembly

Figure 4.5 Valve Cover Assembly

Assembly Number	61-3413-001
Replacement Part Number	
(Less Speaker Screws & Nuts)	60-7000-010
Valve 2 Way V1-V4	62-4294-001
Valve 3 Way V5-V6	62-4293-001
Muffler	62-1340-001
Hose Fitting	62-1342-001
Hose	62-1345-001
Manifold	62-3417-001
Cover Panel	62-3406-001

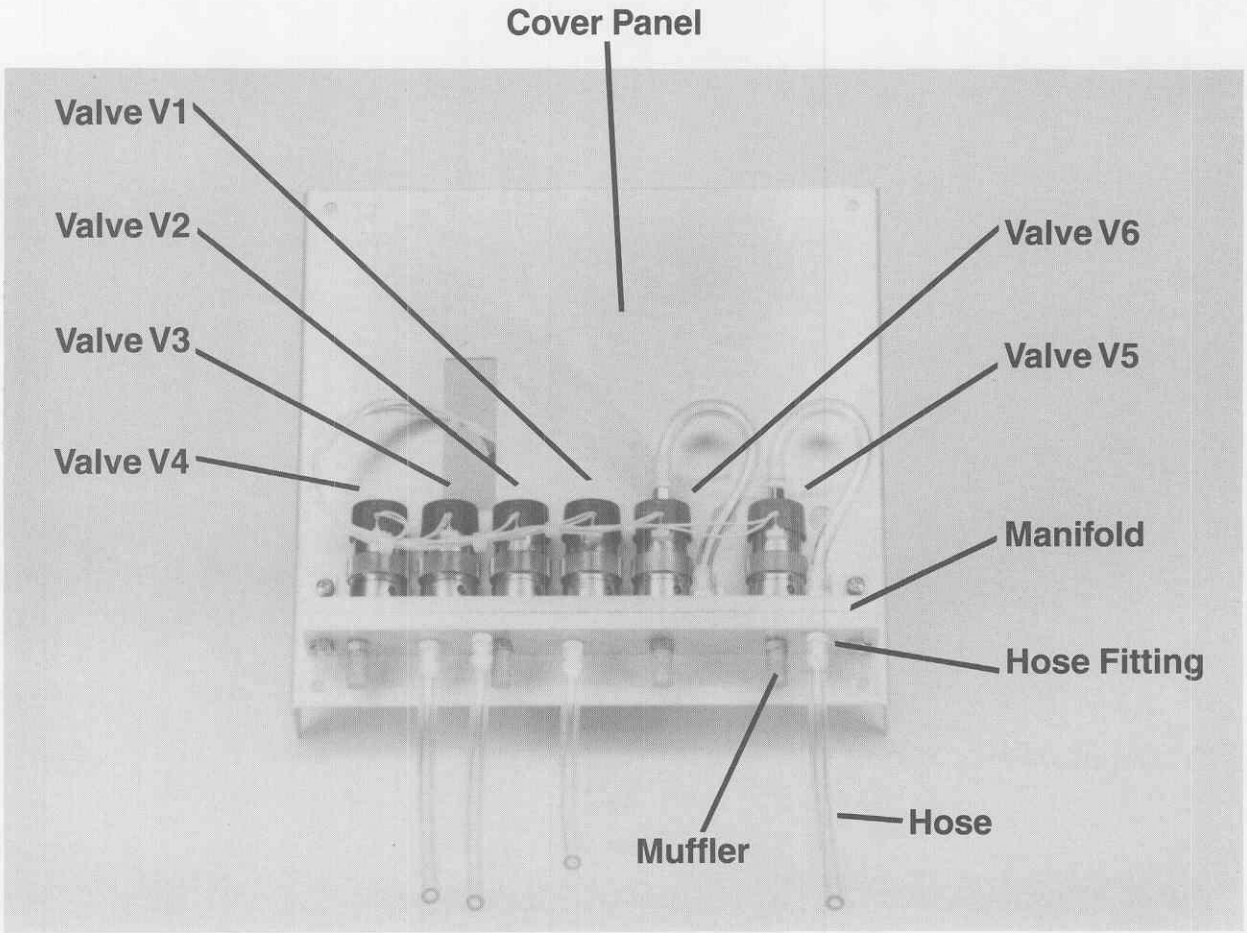

Cover Panel
Valve V1
Valve V2
Valve V3
Valve V4
Valve V6
Valve V5
Manifold
Hose Fitting
Hose
Muffler

Figure 4.6 Internal Assembly Location

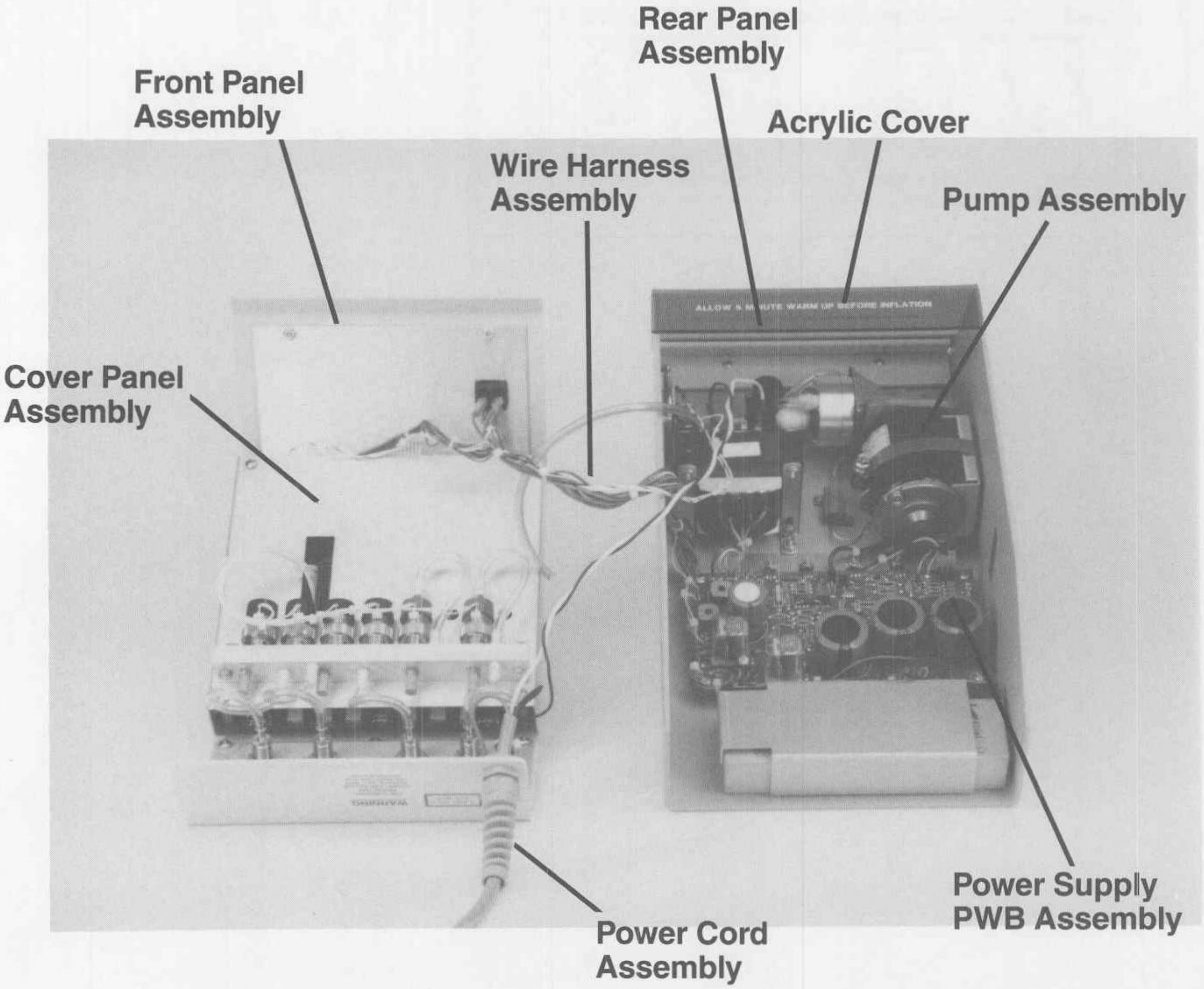

Rear Panel Assembly
Front Panel Assembly
Acrylic Cover
Wire Harness Assembly
Pump Assembly
Cover Panel Assembly
ALLOW 5 MINUTE WARM UP BEFORE INFLATION
Power Supply PWB Assembly
Power Cord Assembly

Figure 4.7 Calibration Setup Assembly

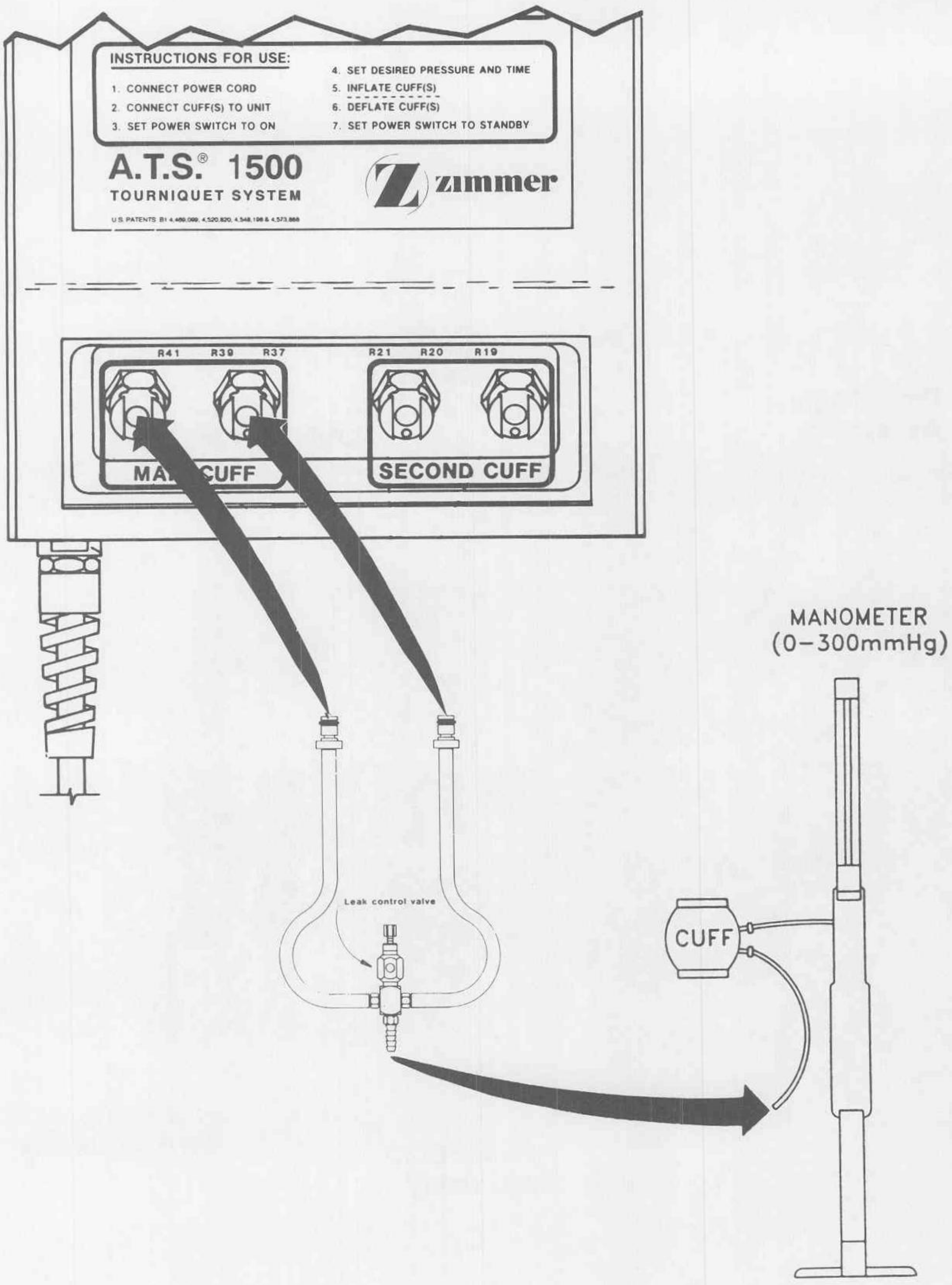
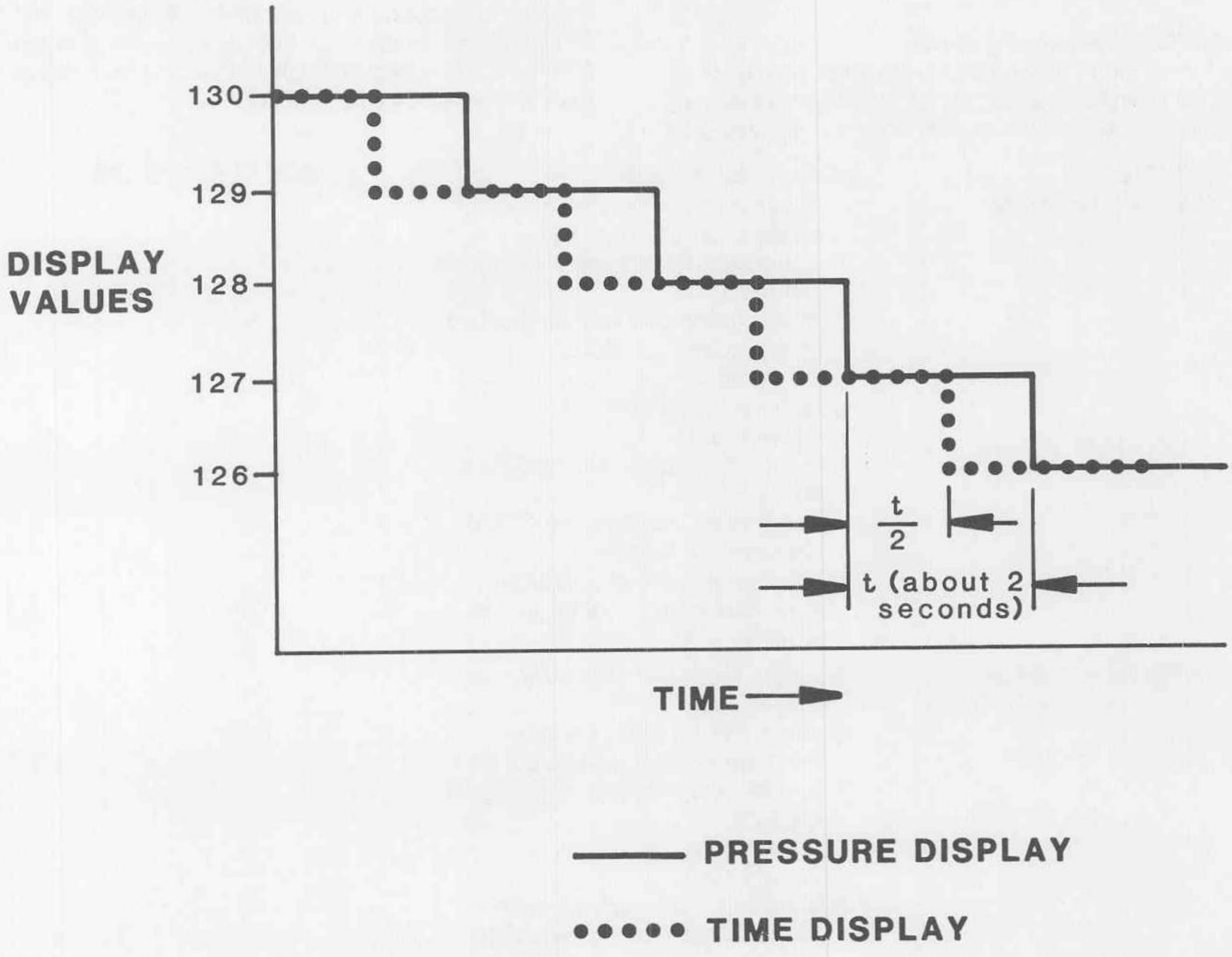

INSTRUCTIONS FOR USE:
1. CONNECT POWER CORD
2. CONNECT CUFF(S) TO UNIT
3. SET POWER SWITCH TO ON
4. SET DESIRED PRESSURE AND TIME
5. INFLATE CUFF(S)
6. DEFLATE CUFF(S)
7. SET POWER SWITCH TO STANDBY
A.T.S.® 1500
TOURNIQUET SYSTEM
zimmer
R41
R39
R37
R21
R20
R19
MA CUFF
SECOND CUFF
Leak control valve
MANOMETER
(0–300mmHg)
CUFF

Figure 4.8 Common-Mode Display Sequence



executing reliable instructions and is not able to display the correct failure message. This failure mode, and all others giving a FAIL message, might be cleared by cycling the ON/STANDBY switch. The calibration error message (CALM FAIL or CAL2 FAIL) may be due to faulty circuitry or may simply indicate the need for calibration. The Watch Dog Timer error message may be due to a faulty Watch Dog Timer circuit or improper microprocessor timing.

4.4.1 Troubleshooting Guide

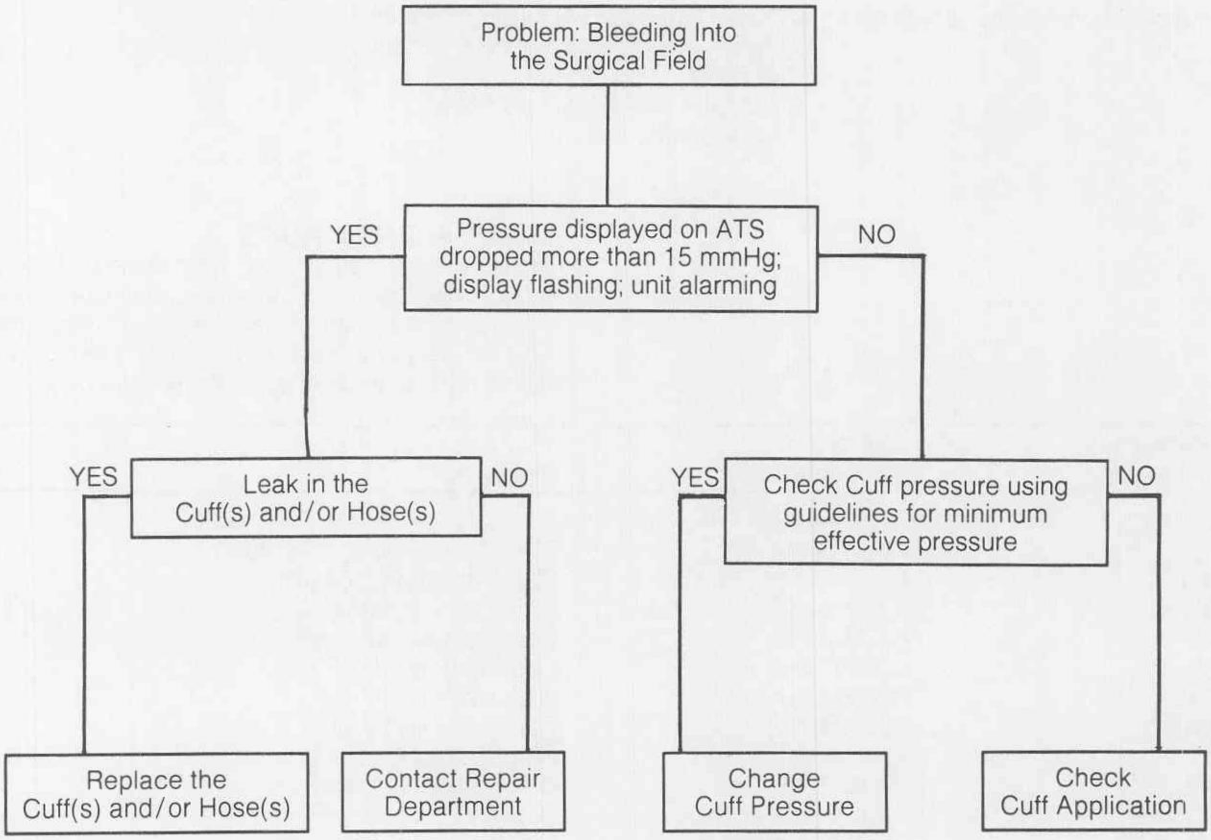
To further aid in unscheduled maintenance, the following list delineates a number of possible malfunctions that could occur with the unit. The most likely causes are shown for each symptom. While it is not practical to enumerate every conceivable malfunction and all possible causes, this list in conjunction with the theory of operation will be of assistance in isolating the most common problems.

Expected readings on the PWB test points are shown in Table 4.2. The measurements are to be made at room temperature with the cuffs disconnected, and the unit plugged in. All voltage measurements are with respect to ground, and are to be made with the ON/STANDBY switch in the ON position. Unless noted otherwise, all reference designators and test points listed below refer to the A1 PWB.

SYMPTOM	POSSIBLE CAUSES	CHECK TEST POINTS
1. Cuff(s) will not inflate	a) Touch-switch panel connector not properly plugged into J3	
	b) Connector J4 not properly plugged into PWB	
	c) Tubing inside unit may be pinched or improperly connected	
	d) U6 defective	
	e) WDT hardware fault	
	f) Valve(s) stuck	
	g) Pump not properly plugged into J1 on A2 PWB	
	h) Pump drive circuitry on A2 PWB damaged or defective	
	i) Inflation of one cuff will not be permitted while the other cuff is inflating	
2. Cuff(s) will not deflate	a) Deflate touch-switch not depressed long enough	
	b) Touch switch panel connector not properly plugged into J3	
	c) Connector J4 not properly plugged into PWB	
	d) U6 defective	
	e) Valve(s) stuck	
	f) Deflation of one cuff will not be permitted while the other cuff is inflating	
3. No displays or tones when ON/STANDBY switch moves to ON	a) Unit not plugged in and battery dead or absent	TP1 or TP4 on A2 PWB
	b) Main Fuse blown and battery dead or absent	
	c) Wire harness not properly plugged into ON/STANDBY switch	
	d) ON/STANDBY switch defective	
	e) Power supply harness not plugged properly into J1	
	f) VR2 on A2 PWB damaged or defective	TP5 on A2 PWB
4. Alarm Silence Switch not working	a) Wire Harness between switch and PWB not properly connected at J2	
	b) Non-silencable alarm (Low Battery Voltage or hardware failure)	
	c) Alarm Silence Switch defective	

SYMPTOM	POSSIBLE CAUSES	CHECK TEST POINTS
5. Frequency at TP3 not in spec.	a) X2, C9, or C10 damaged or defective	TP3
	b) U14 damaged or defective	
6. Frequency at TP1 out of spec.	a) X1, C7, C8, R12, R13, or U11 damaged or defective	TP1
7. Voltage at TP5 or TP6 out of spec.	a) Calibration required	TP5 or TP6
	b) Resistors R101 through R105 not replaced as a set with XDCR1	
	c) XDCR1 faulty	
	d) U18 damaged or defective	
	e) +12 VDC supply not in spec.	TP1 on A2 PWB
8. Voltage at TP8 or TP10 out of spec.	a) Calibration required	TP8 or TP10
	b) U17, U18, or U19 damaged or defective	
	c) Resistors R101 through R105 not replaced as a set with XDCR1	
	d) XDCR1 faulty	
9. Voltage at TP11 or TP12 out of spec.	a) Calibration required	TP11 or TP12
	b) Resistors R201 through R205 not replaced as a set with XDCR2	
	c) XDCR2 faulty	
	d) U21 damaged or defective	
	e) +12 VDC supply out of spec.	TP1 on A2 PWb
10. Voltage at TP13 or TP14 out of spec.	a) Calibration required	TP13 or TP14
	b) U20, U21, or U22 damaged or defective	
	c) Resistors R201 through R205 not replaced as a set with XDCR2	
	d) XDCR2 faulty	
11. No sound during power-up	a) No signal at TP1	TP1
	b) Wiring to speaker faulty or improperly connected	
	c) U1, U3, U4, U5, or U12 damaged or defective	
12. Abnormal operation at power-up	a) U14 or U15 damaged, defective, or improperly seated in socket	TP3
	b) X1, C7, C8, R12, R13, or U11 damaged or defective	
	c) +5 VDC supply out of spec.	TP5 on A2 PWB
	d) Main fuse blown and battery voltage below 10.5 VDC	
13. Abnormal displays during power-up or operation	a) U13 damaged or defective	
	b) U7 damaged or defective	
	c) U8 damaged or defective	
14. Abnormal operation during calibration	a) XDCR1 or XDCR2 faulty	TP8, TP10, TP13 or TP14
	b) Resistors R101 through R105 not replaced as a set with XDCR1	
	c) Resistors R201 through R205 not replaced as a set with XDCR2	
	d) U17, U18, U19, U20, U21 or U22 damaged or defective	
15. Voltage at TP5 of A2 PWB out of spec.	a) VR2 damaged or defective	TP5 on A2 PWB
16. Voltage at TP1 of A2 PWB out of spec.	a) VR1 improperly adjusted or defective	TP1 ON A2 PWB

SYMPTOM	POSSIBLE CAUSES	CHECK TEST POINTS
17. BACKUP BATTERY CHARGING light not on when unit plugged in	a) Main fuse or fuse F1 on A2 PWB blown or absent b) Battery not properly connected, absent or dead c) U1 on A2 PWB damaged or defective d) Power supply harness not properly plugged into J1 e) Battery charging circuit damaged or defective f) Battery voltage below +11.0 VDC g) Power cord/plug damaged or defective NOTE: Battery charging light may go off for varying intervals, if the battery is fully charged or the battery charger has just made a transition between charging states. The light will also be off while the battery charger is attempting to recover a severely discharged battery.	
18. Pump assembly continues to run	a) Leak in system b) Pump drive circuitry on A2 PWB NOTE: The pump assembly has three modes of operation: **OFF, IDLE,** and **RUN**. During idle state the pump will vibrate (oscillate). This is normal condition for the pump.	


Problem: Bleeding Into the Surgical Field
YES
Pressure displayed on ATS dropped more than 15 mmHg; display flashing; unit alarming
NO
YES
Leak in the Cuff(s) and/or Hose(s)
NO
YES
Check Cuff pressure using guidelines for minimum effective pressure
NO
Replace the Cuff(s) and/or Hose(s)
Contact Repair Department
Change Cuff Pressure
Check Cuff Application

*For further information regarding pressure settings and cuff application, contact your local Zimmer Representative.

19. Loss of power when unplugged	a) Fuse F1 on A2 PWB blown or absent b) Battery not properly connect, absent or dead c) Relay K1 on A2 PWB damaged or defective

4.5 REPLACEABLE PARTS

The following is a list of field replaceable parts. Many of the more common parts are available at local electronic suppliers. For ordering parts from Zimmer, see paragraph 4.6. We strongly recommend that all repairs be done by properly trained staff.

Reference Designator	Zimmer Part Number	Description
ASSEMBLY: Logic PWB (A1), 61-3404-001		
A1	62-3403-001	PWB, Logic Board, A.T.S. 1500
C1	62-2720-003	Cap, Electrolytic, 100 μF
C2-C4	62-2718-006	Cap, Ceramic, 0.1 μF
C5	62-2718-004	Cap, Ceramic, 4700 pF
C6	62-2718-006	Cap, Ceramic, 0.1 μF
C7-C8	62-2718-001	Cap, Ceramic, 22 pF
C9-C10	62-2718-002	Cap, Ceramic, 33 pF
C11	62-3305-001	Cap, Tantalum, 22 μF
C12	62-1357-001	Cap, Tantalum, 1 μF
C13-C14	62-1854-001	Cap, Tantalum, 10 μF
C15	62-2718-006	Cap, Ceramic, 0.1 μF
C16	62-2718-004	Cap, Ceramic, 4700 pF
C17	62-2844-001	Cap, Film, 1 μF
C18-C20	62-2718-004	Cap, Ceramic, 4700 pF
C21	62-2844-001	Cap, Film, 1 μF
C22-C29	62-0267-002	CAP, Ceramic, 0.1 μF
CR1-CR4	62-0290-001	Diode, 1N914A
CR5	62-3446-001	Diode, Zener, 1N5230B
CR6-CR7	62-0290-002	Diode, 1N914B
I1-I4	62-3399-001	LED, 14 Segment Alphanumeric
I5-I7	62-1360-002	LED, Light Bar, Yellow
J1	62-1390-008	Header
J2	62-1390-003	Receptacle, 4 Pin
J3	62-3402-001	Header, 9 Pin
J4	62-2845-014	Receptacle, 15 Pin
Q1-Q2	62-0412-001	Transistor, PNP
R1-R2	62-0365-043	Resistor, 150, ½ W, 5%
R3	62-0365-033	Resistor, 56, ½ W, 5%
R4	62-0365-047	Resistor, 220, ½ W, 5%
R5-R6	62-0364-107	Resistor, 68K, ¼ W, 5%
R7-R8	62-0364-101	Resistor, 39K, ¼ W, 5%
R9	62-0364-079	Resistor, 4.7K, ¼ W, 5%
R10	62-0364-095	Resistor, 22K, ¼ W, 5%
R11-R12	62-0364-087	Resistor, 10K, ¼ W, 5%
R13	62-0364-159	Resistor, 10M, ¼ W, 5%
R14	62-0364-063	Resistor, 1K, ¼ W, 5%
R15	62-0364-135	Resistor, 1M, ¼ W, 5%
R16	62-0364-119	Resistor, 220K, ¼ W, 5%
R17	62-0961-198	Resistor, 1.13K, ¼ W, 1%

Reference Designator	Zimmer Part Number	Description
R18	62-0961-326	Resistor, 24.3K, ¼ W, 1%
R19	62-1359-003	Potentiometer, 100K, 20T
R20	62-1359-001	Potentiometer, 1K, 20T
R21	62-1359-002	Potentiometer, 10 K, 20T
R22	62-0364-085	Resistor, 8.2K, ¼ W, 5%
R23	62-0364-101	Resistor, 39K, ¼ W, 5%
R24-R25	62-0364-087	Resistor, 10K, ¼ W, 5%
R26	62-3484-002	Potentiometer, 2K, 20T
R27	62-0961-383	Resistor, 95.3K, ¼ W, 1%
R28-R29	62-0961-201	Resistor, 1.21K, ¼ W, 1%
R30	62-0961-383	Resistor, 95.3K, ¼ W, 1%
R31	62-0961-126	Resistor, 200, ¼ W, 1%
R32-R33	62-0961-383	Resistor, 95.3K, ¼ W, 1%
R34-R35	62-0364-079	Resistor, 4.7K, ¼ W, 5%
R36	62-0961-201	Resistor, 1.21K, ¼ W, 1%
R37	62-1359-003	Potentiometer, 100K, 20T
R38	62-0961-198	Resistor, 1.13K, ¼ W, 1%
R39	62-1359-001	Potentiometer, 1K, 20T
R40	62-0961-326	Resistor, 24.3K, ¼ W, 1%
R41	62-1359-002	Potentiometer, 10K, 20T
R42	62-0961-126	Resistor, 200, ¼ W, 1%
R43	62-0364-063	Resistor, 1K, ¼ W, 5%
R44	62-0961-383	Resistor, 95.3K, ¼ W, 1%
R45-R46	62-0364-079	Resistor, 4.7K, ¼ W, 5%
R47	62-0961-201	Resistor, 1.21K, ¼ W, 1%
R48-R50	62-0961-383	Resistor, 95.3K, ¼ W, 1%
R51	62-0364-071	Resistor, 2.2K, ¼ W, 5%
R52	62-0364-015	Resistor, 10, ¼ W, 5%
R53	62-0364-098	Resistor, 30K, ¼ W, 5%
R54-R55	62-0364-077	Resistor, 3.9K, ¼ W, 5%
R56	62-0364-098	Resistor, 30K, ¼ W, 5%
RN1	62-2722-001	Resistor Network, SIP, 39K, 7 Pin
RN2-RN3	62-2721-001	Resistor Network, SIP, 68K, 6 Pin
RN4-RN5	62-2861-001	Resistor Network, SIP, 4.7K, 9 Pin
TP1-TP15	62-2725-001	Test Point, 0.200 in. Centers
U1	62-1374-001	I.C., O.C. Driver, ULN2003
U2	62-3397-001	I.C., EPLD, 300 Gate
U3	62-3395-001	I.C., EPLD, 600 Gate
U4-U5	62-2572-001	I.C., Divider, CD4040
U6	62-3393-001	I.C., Latch, 74HC573
U7	62-2573-001	I.C., NAND Gate, CD4011
U8	62-3400-001	I.C., Latch, 74HC259
U9	62-2570-001	I.C., AND Gate, CD4081
U10	62-1374-001	I.C., O.C. Driver, ULN2003
U11	62-1373-001	I.C., Inverter, CD4069
U12	62-2727-001	I.C., 4 Bit Latch, CD40175
U13	62-3396-001	I.C., Alphanumeric Display, ICM7243B
U14	62-3405-001	I.C., Microprocessor, 80C31
U15	62-3398-001	I.C., EPROM, 87C64
U16	62-2577-001	I.C., A/D Converter, ADC0808
U17	62-1363-001	I.C., Op Amp, CA3160A
U18	62-1362-001	I.C., Dual Op Amp, LM358
U19-U20	62-1363-001	I.C., Op Amp, CA3160A
U21	62-1362-001	I.C., Dual Op Amp, LM358
U22	62-1363-001	I.C., Op Amp, CA3160A

Reference Designator	Zimmer Part Number	Description
X1	62-1378-002	Crystal, 2.00 MHz
X2	62-1378-001	Crystal, 3.58 MHz
XDCR1-XDCR2	62-1376-001	Pressure Transducer
XU2	62-4433-001	Socket, 20 Pin
XU3	62-4434-001	Socket, 24 Pin
XU14	62-1377-009	Socket, 40 Pin
XU15	62-1377-008	Socket, 28 Pin
	62-1345-001	Hose, ⅛ in. I.D., Buna-N
ASSEMBLY: Power Supply PWB (A2), 61-3378-001		
A2	62-3379-001	PWB, Power Supply
C1	62-1357-001	Cap, Tantalum, 1 μF
C2	62-1854-001	Cap, Tantalum, 10 μF
C3	62-3314-001	Cap, Electrolytic, 4700 μF
C4	62-3305-001	Cap, Tantalum, 22 μF
C5	62-2718-007	Cap, Ceramic, 0.33 μF
C6	62-0268-004	Cap, Electrolytic, 470 μF
C7-C9	62-3314-002	Cap, Electrolytic, 10000 μF
C10-C11	62-2718-007	Cap, Ceramic, 0.33 μF
C12	62-1854-001	Cap, Tant, 10 μF
C13	62-0268-007	Cap, Elec., 100μF
CR1-CR2	62-0258-002	Diode Bridge, VJ148
CR3-CR8	62-0565-001	Diode, 1N4004
CR9	62-3313-001	Diode, Shottkey, 1N5821
CR10	62-1327-001	Diode, 1N5400
CR11-CR12	62-0565-001	Diode, 1N4004
CR13	62-3313-001	Diode, 1N5821
CR14	62-0290-001	Diode, 1N914A
J1	62-3598-001	Header
K1-K2	62-3307-001	Relay, DPDT
Q1	62-3306-001	Transistor, PNP, TIP32
Q2	62-0412-001	Transistor, PNP, MPS6533
Q3	62-1330-001	Transistor, NPN, MJ3055T
R1	62-0364-064	Resistor, 1.1K, ¼ W, 5%
R2	62-0963-002	Potentiometer, 500, 1T
R3	62-0364-043	Resistor, 150, ¼ W, 5%
R4	62-0366-059	Resistor, 680, 1 W, 5%
R5	62-0364-041	Resistor, 120, ¼ W, 5%
R6	62-0961-347	Resistor, 40.2K, ¼ W, 1%
R7	62-2973-001	Resistor, 0.50, 1 W, 1%
R8	62-0961-412	Resistor, 191K, ¼ W, 1%
R9-R10	62-0961-414	Resistor, 200K, ¼ W, 1%
R11	62-0961-273	Resistor, 6.81K, ¼ W, 1%
R12	62-1359-006	Potentiometer, 20K, 20T
R13	62-0364-099	Resistor, 33K, ¼ W, 5%
R14	62-0364-051	Resistor, 330, ¼ W, 5%
R15	62-0961-300	Resistor, 13.0K, ¼ W, 1%
R16	62-0961-409	Resistor, 178K, ¼ W, 1%
R17	62-0961-444	Resistor, 412K, ¼ W, 1%
R18	62-0961-414	Resistor, 200K, ¼ W, 1%
R19	62-0963-008	Potentiometer, 20 K, 1T
R20	62-0364-039	Resistor, 100, ¼ W, 5%
R21	62-0364-025	Resistor, 27, ¼ W, 5%
R22	62-0364-089	Resistor, 12K, ¼ W, 5%

Reference Designator	Zimmer Part Number	Description
R23	62-0364-073	Resistor, 2.7K, ¼ W, 5%
R24	62-0366-046	Resistor, 200, 1 W, 5%
R25	62-2973-002	Resistor, 0.50, 10 W, 1%
R26	62-0366-059	Resistor, 680, 1 W, 5%
R27-28	62-0364-070	Resistor, 2K, ¼ W, 5%
TP1-TP7	62-2725-001	Test Point, 0.200 in. Centers
U1	62-1362-001	I.C., Dual Op Amp, LM358
U2	62-3304-001	I.C., Battery Charger, UC3906J
VR1	62-1329-002	Voltage Regulator, Adj.
VR2	62-0417-004	Voltage Regulator, 5V + 2%
W1	61-3430-001	Wire Harness Assembly, A2
XF1-XF2	62-0295-001	Fuse Clip (2)
	62-0260-001	Cable Ties (6)
	62-0288-004	Terminals, 0.187, Slip-on (2)
	62-0434-001	Wire, 22 AWG, Stranded, Yellow (12.5 in.)
	62-0436-001	Wire, 18 AWG, Stranded, Red (6 in.)
	62-0436-003	Wire, 18 AWG, Stranded, Orange (4.5 in.)
	62-0436-004	Wire, 18 AWG, Stranded, Yellow (4.5 in.)
	62-0436-006	Wire, 18 AWG, Stranded, Gray (4.5 in.)
	62-0436-007	Wire, 18 AWG, Stranded, Green (4.5 in.)
	62-0436-008	Wire, 18 AWG, Stranded, Black (4 in.)
	62-2985-001	Terminal, Soldertail (2)
	62-3598-001	Header

A.T.S. 1500

Reference Designator	Zimmer Part Number	Description
ASSEMBLY: Rear Panel (A3), 61-3413-001		
A2	61-3378-001	Power Supply PWB Assembly
B1	62-3428-001	Battery, 12V, 1.9 AH
M1	62-1297-001	Pump Assembly
P1	62-3682-003	Receptacle
R1	62-1688-002	Resistor, 1 ohm, 25 W
T1	62-3411-001	Transformer, 100V/120V
	62-0260-001	Cable Tie, Small (5)
	62-0323-003	Grommet (4)
	62-0341-001	Nut, Small Pattern #4-40 (2)
	62-0343-001	Nut, Keps #4-40 (4)
	62-0343-002	Nut, Keps #6-32 (4)
	62-0343-003	Nut, Keps #8-32 (10)
	62-0376-012	Screw, B.H.S., #4-40 x 1⅛″ (2)
	62-0378-003	Screw, B.H.S., #8-32 x ¼″ (4)
	62-0419-002	Washer, Flat #4 (6)
	62-0419-003	Washer, Flat #6 (4)
	62-0620-005	Heat Shrinkable Tubing (3″)
	62-0649-001	Thread Sealer
	62-0974-001	Retainer, Foam, Battery (1)
	62-1284-001	Hinge, Cover (1)
	62-1335-001	Washer, Shoulder, TO-220 (4)
	62-1342-001	Hose Fitting, Barb (2)
	62-1345-001	Hose, Buna-N, ⅛″ ID (6″)
	62-3682-201	Terminal (2)
	62-1352-001	Clamp, Hose, Pump (1)
	62-2079-001	Screw, Truss Head, #6-32 x 3/16″ (2)
	62-2360-001	Knob, 5 Lobe Plastic (1)
	62-2408-001	Jaw, Pole Clamp (1)
	62-2440-001	Screw, Set, ¼-20 Hex Socket (1)
	62-2546-001	Screw, Pole Clamp (1)
	62-2547-001	Hex Nut, Pole Clamp (1)
	62-2549-001	Washer, Pole Clamp (1)
	62-2971-001	Bearing, Pole Clamp, Special (1)
	62-2972-003	Body, Pole Clamp, Brown (1)
	62-3302-001	Regulator, Overpressure (1)
	62-3347-001	Rear Panel (1)
	62-3407-001	Battery Box (1)
	62-3408-001	Bracket, Pump (1)
	62-3409-001	Spacer, ¼″ (4)
	62-3425-001	Plate, Hinge (1)
	62-3427-001	Gasket, Buna-N (2)
	62-3429-001	Insulator, Silicone, TO-220 (4)
	62-0333-001	Speaker (1)
	62-0433-004	Wire, 24AWG, Stranded, Wht/Blk, 26.5" 1)
	62-0433-006	Wire, 24AWG, Stranded, Wht/Org, 26.5" (1)
	62-1389-001	2 Pin Connector (1)
	62-1388-001	Terminal, Crimp Fishook (2)

Reference Designator	Zimmer Part Number	Description
ASSEMBLY: Front Panel (A4), 61-3414-001		
A1	61-3404-001	Logic PWB Assembly
A5	61-3433-001	Cover Panel Assembly
F1	62-1253-005	Fuse, 0.5A, Slo-Blo
S1	62-2421-001	Switch, Power
S2	62-1384-001	Switch, Momentary Pushbutton
W1	61-3435-001	Wire Harness
XF1	62-1254-001	Fuseholder
	62-0260-001	Cable Tie, Small (1)
	62-0335-004	Standoff, Nylon, ¼″ Hex, 6-32
	62-0343-002	Nut, Keps #6-32 (14)
	62-0378-005	Screw, B.H.S. #8-32 x ⅜″ (4)
	62-1345-001	Hose, Buna-N ⅛″ ID (12″)
	62-1346-001	Standoff, #8-32 M-F, 1 x ¼″ Hex (4)
	62-1385-001	Lens Cap (1)
	62-1391-001	Lamp (1)
	62-2043-001	Lockwasher, Int. Toothed, ½″ (4)
	62-2662-002	Nameplate, Front Panel (1)
	62-2671-001	Pneumatic Coupling, Female (4)
	62-2982-001	Label, Fuse Rating (1)
	62-3285-001	Switch Panel (1)
	62-3312-001	Output Panel (1)
	62-3346-001	Front Panel (1)
	62-3418-001	Label, Output Panel (1)
ASSEMBLY: Cover Panel (A5), 61-3433-001		
P4	62-1389-011	12 Pin Connector (1)
V1-V4	62-4294-001	Valve, Manifold, 2 Way
V5-V6	62-4293-001	Valve, Manifold, 3 Way
	62-0260-001	Cable Tie, Small (7)
	62-0343-002	Nut, Keps #6-32 (2)
	62-0377-003	Screw, B.H.S. #6-32 x ¼" (2)
	62-0377-009	Screw, B.H.S. #6-32 x ¾" (2)
	62-0649-001	Thread Sealant
	62-1340-001	Muffler (4)
	62-1342-001	Hose Fitting, Barb (11)
	62-1345-001	Hose, Buna-N, ⅛" ID (45")
	62-1388-001	Terminal, Crimp Fishook (12)
	62-3406-001	Cover Panel (1)
	62-3417-001	Manifold, Valve (1)
	62-3426-001	Bracklet, Angle (2)

Reference Designator	Zimmer Part Number	Description
ASSEMBLY: Wire Harness, 61-3430-001		
	62-0260-001	Cable Tie, Small (8)
	62-0288-004	Terminal, Slip-On, 0.187″ Red (4)
	62-0433-001	Wire, 24 AWG, Stranded, Blue (34″)
	62-0433-005	Wire, 24 AWG, Stranded, White/Red (28″)
	62-0433-009	Wire, 24 AWG, Stranded, Gray (34″)
	62-0433-010	Wire, 24 AWG, Stranded, Violet (29″)
	62-0433-012	Wire, 24 AWG, Stranded, Yellow (25″)
	62-0434-003	Wire, 22 AWG, Stranded, Green (66″)
	62-0434-005	Wire, 22 AWG, Stranded, Red (29″)
	62-0434-006	Wire, 22 AWG, Stranded, Orange (33″)
	62-0436-001	Wire, 18 AWG, Stranded, Red (45″)
	62-0436-006	Wire, 18 AWG, Stranded, Gray (49″)
	62-1388-001	Terminal, Crimp Fishhook (9)
	62-1389-008	Connector Plug, 9 Pin (1)
ASSEMBLY: Wire Harness W1, 61-3435-001		
	62-0434-001	Wire, 22 AWG, Stranded, Yellow (5″)
	62-0434-002	Wire, 22 AWG, Stranded, Green (5″)
	62-0434-004	Wire, 22 AWG, Stranded, Brown (5″)
	62-0434-006	Wire, 22 AWG, Stranded, Orange (5″)
	62-1388-001	Terminal, Crimp Fishhook (4)
	62-1389-003	Connector Plug, 4 Pin (1)
ASSEMBLY: Power Cord, 61-3445-001		
	62-0260-001	Cable Tie, Small (5)
	62-0287-004	Ring Lug, #8 Red (1)
	62-0352-001	Plug, 120V, Hospital Grade (1)
	62-0436-008	Wire, 18 AWG, Stranded, Black (18″)
	62-0808-002	Cable, 18-3, SJT, (14′ 7″)
	62-1539-001	Tubing, Heat Shrinkable, ⅜″ (3″)

Reference Designator	Zimmer Part Number	Description
ASSEMBLY: Final, *A.T.S.* 1500, 60-4000-001		
A3	61-3413-001	Rear Panel Assembly
A4	61-3414-001	Front Panel Assembly
	60-4019-002	Manual, Operator & Service (2)
	60-4020-001	Reference Card, Operators (1)
	60-4020-002	Reference Card, Operators (1)
	61-3445-001	Power Cord Assembly (1)
	62-0007-001	Nameplate (1)
	62-0260-001	Cable Tie, Small (1)
	62-0293-001	Fuse, 3 Amp, 3AG (1)
	62-0343-003	Nut, Keps, #8-32 (1)
	62-0378-005	Screw, B.H.S., #8-32 x 3/8" (4)
	62-0438-001	Bead Chain (9")
	62-0439-001	Link, Bead Chain (1)
	62-0620-004	Sleeving, Heat Shrinkable, 3/16" (1.5")
	62-0620-005	Sleeving, Heat Shrinkable, 1/8" (3")
	62-0649-001	Thread Sealant
	62-1256-001	Strain Relief (1)
	62-1257-001	Nut, Strain Relief (1)
	62-1286-002	Trim Plate, Hinge, Exterior (1)
	62-1313-001	Trim Plate, Hinge, Interior (1)
	62-1399-001	Retainer, Power Cord (1)
	62-1556-001	Loquic Primer N
	62-2079-001	Screw, Truss Head #6-32 x 3/16" (2)
	62-3424-001	Cover, Acrylic (1)
	62-3434-001	Shipping Carton (1)
	62-3439-001	Instapak Mold Form, Bottom (1)
	62-3439-002	Instapak Mold Form, Top (1)
	62-4030-001	Video Tape

4.6 PARTS ORDERING INFORMATION

The following is a list of parts that can be ordered from Zimmer. To obtain parts or additional information regarding your unit, write or phone:

MAIL: Zimmer Patient Care Division
200 West Ohio Avenue
Dover, OH 44622
PHONE: (330) 343-8801 or
1-800-321-5533

or contact your local Zimmer distributor. To ensure prompt service, please include the following information with your order:

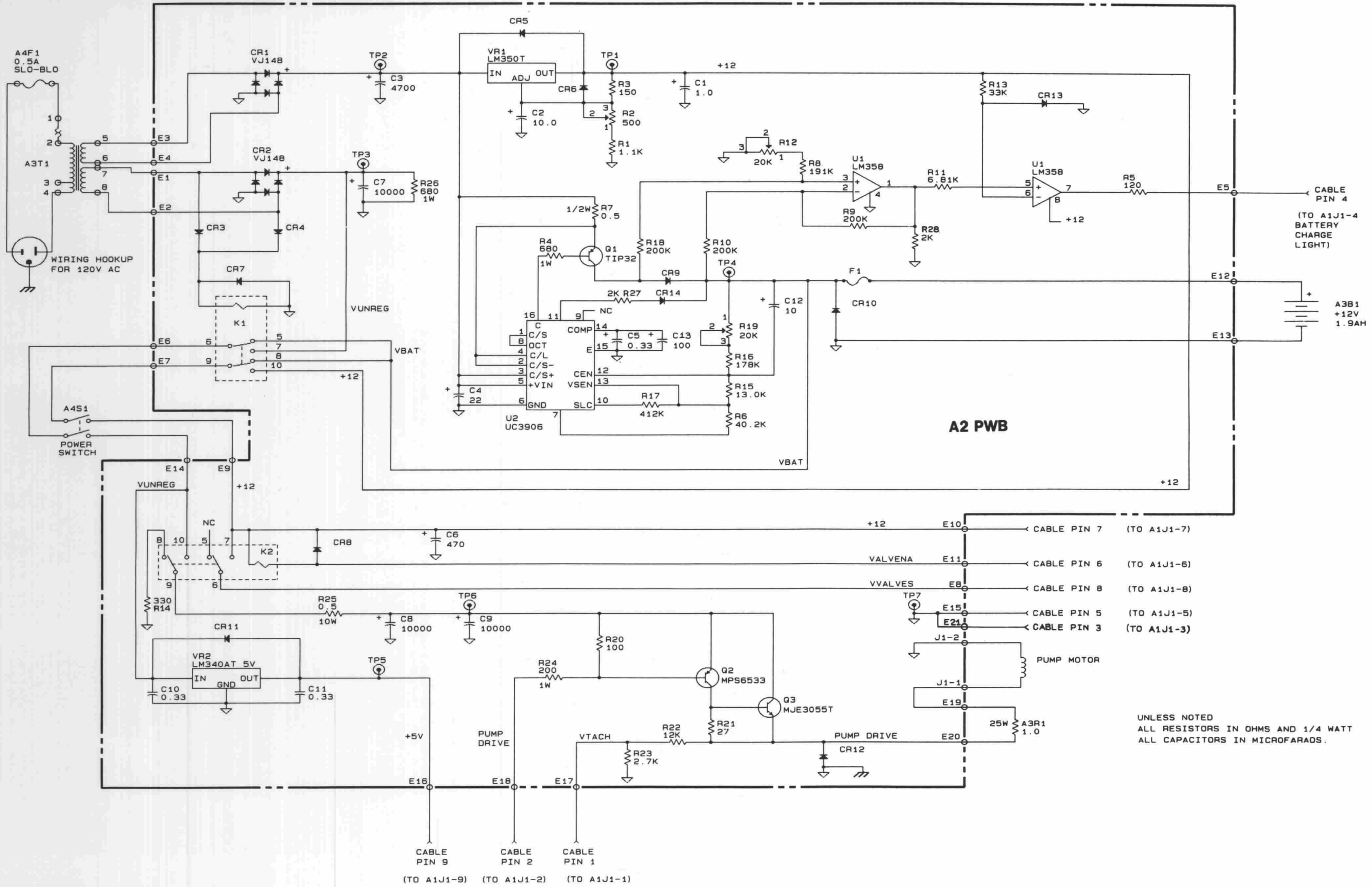
Model Number
Serial Number
Description of Part
Part Number (if known)
Quantity Desired
Shipping Address
Shipping Means (if any)
Purchase Order Number
Your Name

Product Number	Description
60-7000-001-00	*A.T.S.*1500 LOGIC BOARD Includes: 61-3395-001 61-3397-001 62-3405-001 62-2577-001 62-1378-001 62-1378-002
60-7000-002-00	*A.T.S.*1500 POWER SUPPLY BOARD Includes: 62-3304-001 62-3307-001 62-0258-002 62-3313-001 62-0417-004
60-7000-003-00	*A.T.S.*1500 VALVE COVER Includes: 62-4294-001 62-4293-001 62-1388-001 62-3417-001
60-7000-004-00	*A.T.S.*1500 TRANSDUCER Includes: 62-1376-001 62-1363-001 62-1362-002
60-7000-008-00	*A.T.S.*1500 PUMP ASSEMBLY Includes: 62-1297-001-00 62-3682-201-00 62-0260-001-00
60-7000-009-00	*A.T.S.*1500 SWITCH PANEL Includes: 62-3285-001-00
60-7000-010-00	*A.T.S.*1500 COVER PANEL Includes all parts for: 61-3433-001
60-7000-011-00	*A.T.S.*1500 WIRE HARNESS Includes all parts for: 61-3430-001
60-7000-012-00	*A.T.S.*1500 WIRE HARNESS Includes all parts for: 61-3435-001

A.T.S. 1500

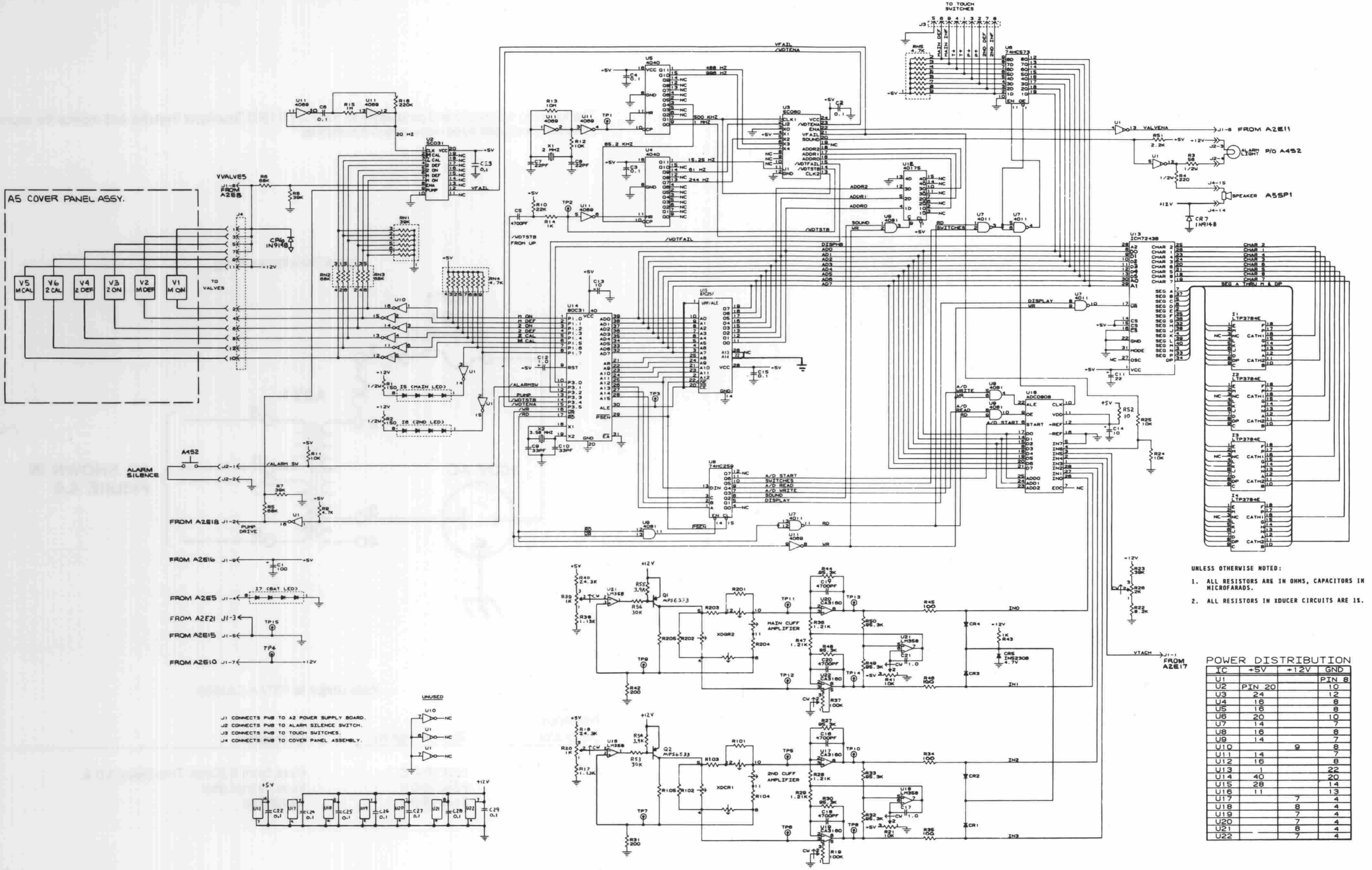
Product Number	Description
60-7000-013-00	*A.T.S.*1500 POWER CORD Includes all parts for: 61-3445-001
60-7000-020	HOSE COUPLING Includes: 62-2879-001
60-7000-021	*A.T.S.*LUER FITTING Includes: 62-1446-01
60-7000-022	ACRYLIC COVER Includes: 62-3424-001
60-7000-024	COVER HINGE Includes: 62-1284-01
60-1468-003	CALIBRATION KIT
60-4018-001	RED HOSE
60-4019-001	BLUE HOSE
60-4022-001	IV STAND
60-1908-001	ACCESSORY BASKET
62-3428-001	BATTERY

Figure 4.9 Schematic Diagram, A2 Power Supply


A4F1
0.5A
SLO-BLO
A3T1
WIRING HOOKUP
FOR 120V AC
CR1
VJ148
CR2
VJ148
TP2
C3
4700
TP3
C7
10000
R26
680
1W
CR3
CR4
CR7
K1
VUNREG
VBAT
+12
E3
E4
E1
E2
E6
E7
A4S1
POWER
SWITCH
E14
E9
CR5
VR1
LM350T
IN
ADJ
OUT
CR6
C2
10.0
TP1
R3
150
R2
500
R1
1.1K
C1
1.0
R12
20K
R8
191K
U1
LM358
R9
200K
R11
6.81K
R28
2K
R13
33K
CR13
R5
120
E5
CABLE
PIN 4
(TO A1J1-4
BATTERY
CHARGE
LIGHT)
R7
1/2W
0.5
R4
680
1W
Q1
TIP32
R18
200K
R10
200K
TP4
CR9
2K R27
CR14
F1
CR10
C12
10
E12
E13
A3B1
+12V
1.9AH
NC
C
C/S
OCT
C/L
C/S-
C/S+
+VIN
GND
COMP
E
CEN
VSEN
SLC
C5
0.33
C13
100
R19
20K
R16
178K
R15
13.0K
R17
412K
R6
40.2K
C4
22
U2
UC3906
A2 PWB
VUNREG
K2
CR8
C6
470
E10
E11
E8
VALVENA
VVALVES
CABLE PIN 7 (TO A1J1-7)
CABLE PIN 6 (TO A1J1-6)
CABLE PIN 8 (TO A1J1-8)
CABLE PIN 5 (TO A1J1-5)
CABLE PIN 3 (TO A1J1-3)
TP7
E15
E21
J1-2
PUMP MOTOR
J1-1
E19
25W
A3R1
1.0
E20
PUMP DRIVE
CR12
330
R14
R25
0.5
10W
C8
10000
TP6
C9
10000
R20
100
CR11
VR2
LM340AT 5V
IN
GND
OUT
C10
0.33
C11
0.33
TP5
R24
200
1W
Q2
MPS6533
Q3
MJE3055T
R22
12K
R21
27
R23
2.7K
+5V
PUMP
DRIVE
VTACH
E16
E18
E17
CABLE
PIN 9
(TO A1J1-9)
CABLE
PIN 2
(TO A1J1-2)
CABLE
PIN 1
(TO A1J1-1)

UNLESS NOTED
ALL RESISTORS IN OHMS AND 1/4 WATT
ALL CAPACITORS IN MICROFARADS.

Figure 4.10 Schematic Diagram, A1 Logic Board


A5 COVER PANEL ASSY.
V5 M CAL
V6 2 CAL
V4 2 DEF
V3 2 ON
V2 M DEF
V1 M ON
TO VALVES
VVALVES
FROM A2E8
TO TOUCH SWITCHES
U5 4040
U4 4040
U3 SC080
U2 SC031
U14 80C31
U15 27C257
U6 74HC573
U13 ICM7243B
U16 ADC0808
U8 74HC259
I1 LTP3784E
I2 LTP3784E
I3 LTP3784E
I4 LTP3784E
VALVENA
FROM A2E11
ALARM LIGHT P/O A4S2
SPEAKER A5SP1
ALARM SILENCE
A4S2
FROM A2E18
PUMP DRIVE
FROM A2E16
FROM A2E5
I7 (BAT LED)
FROM A2E21
FROM A2E15
FROM A2E10
I5 (MAIN LED)
I6 (2ND LED)
MAIN CUFF AMPLIFIER
2ND CUFF AMPLIFIER
XDCR2
XDCR1
Q1 MPS6533
Q2 MPS6533
VTACH
FROM A2E17
UNUSED
DISPLAY WR
A/D WRITE
A/D READ
A/D START
SWITCHES
SOUND
DISPLAY

UNLESS OTHERWISE NOTED:

1. ALL RESISTORS ARE IN OHMS, CAPACITORS IN MICROFARADS.
2. ALL RESISTORS IN XDUCER CIRCUITS ARE 1%.

J1 CONNECTS PWB TO A2 POWER SUPPLY BOARD.
J2 CONNECTS PWB TO ALARM SILENCE SWITCH.
J3 CONNECTS PWB TO TOUCH SWITCHES.
J4 CONNECTS PWB TO COVER PANEL ASSEMBLY.

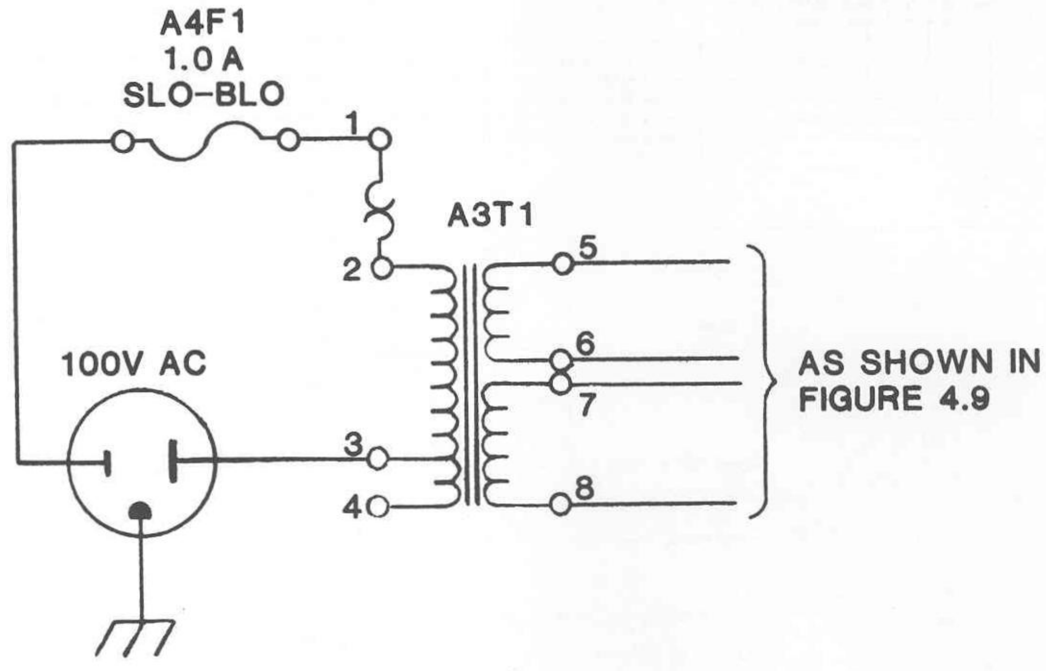
POWER DISTRIBUTION

IC	+5V	+12V	GND
U1			PIN 8
U2	PIN 20		10
U3	24		12
U4	16		8
U5	16		8
U6	20		10
U7	14		7
U8	16		8
U9	14		7
U10		9	8
U11	14		7
U12	16		8
U13	1		22
U14	40		20
U15	28		14
U16	11		13
U17		7	4
U18		8	4
U19		7	4
U20		7	4
U21	—	8	4
U22		7	4

Section 4.7 100V Version

The following schematic and parts apply to 100V *A.T.S.*1500 Tourniquet Systems and replace the equivalent schematic and parts listed elsewhere in this manual.

Power Transformer Wiring


A4F1
1.0 A
SLO-BLO
1
2
3
4
A3T1
5
6
7
8
100V AC
AS SHOWN IN FIGURE 4.9

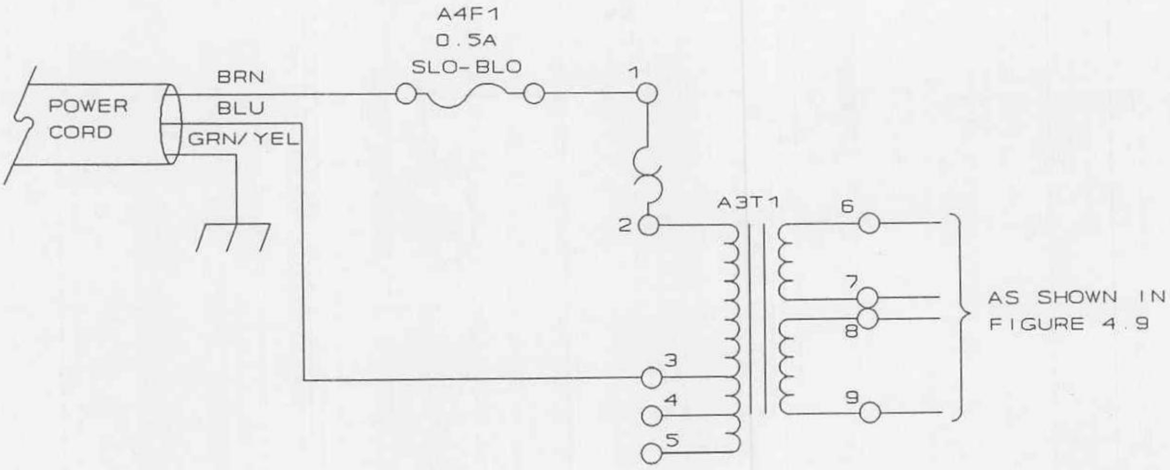
Parts unique to 100V *A.T.S.*1500

Reference Designator	Zimmer Part No.	Description
A4F1	62-3367-003	Fuse, 5mm X 20mm, Time Delay, 1.0 A
	62-4910-001	Fuse Rating Label
	61-4276-001	Nameplate

Section 4.8 220V Version

The following schematic and parts apply to 220V *A.T.S.*1500 Tourniquet Systems and replace the equivalent schematic and parts listed elsewhere in this manual.

Power Transformer Wiring


A4F1
0.5A
SLO-BLO
BRN
BLU
GRN/YEL
POWER
CORD
1
2
A3T1
6
7
8
9
3
4
5
AS SHOWN IN
FIGURE 4.9

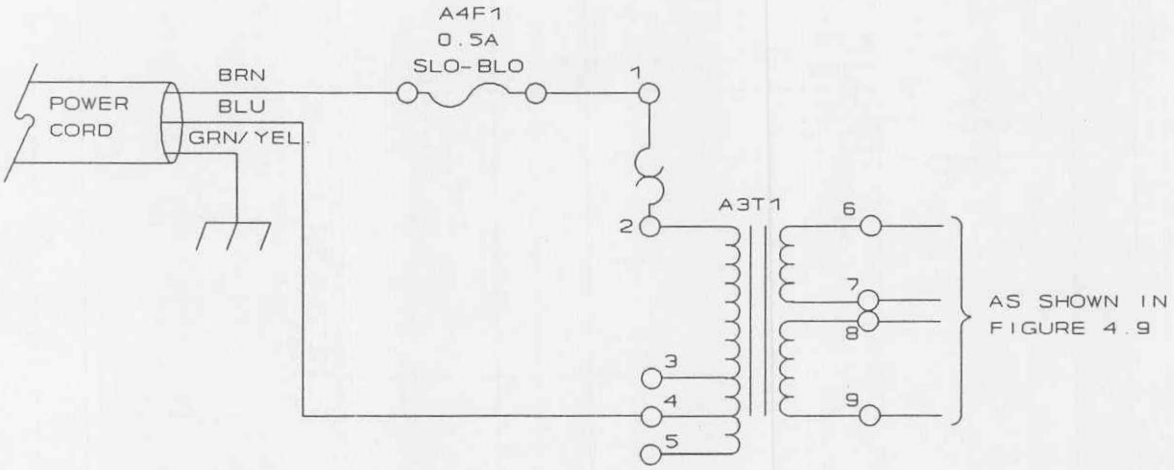
Parts unique to 220V *A.T.S.*1500

Reference Designator	Zimmer Part No.	Description
A4F1	62-1253-005	FUSE, 5mm X 20mm, TIME DELAY, 0.5A
	62-2982-001	FUSE RATING LABEL
A3T1	62-4476-001	TRANSFORMER
	61-4477-001	NAMEPLATE
	61-4478-001	POWER CORD ASSEMBLY

Section 4.9 240V Version

The following schematic and parts apply to 240V *A.T.S.* 1500 Tourniquet Systems and replace the equivalent schematic and parts listed elsewhere in this manual.

Power Transformer Wiring


A4F1
0.5A
SLO-BLO
POWER CORD
BRN
BLU
GRN/YEL
1
2
3
4
5
A3T1
6
7
8
9
AS SHOWN IN FIGURE 4.9

Parts unique to 240V *A.T.S.* 1500

Reference Designator	Zimmer Part No.	Description
A4F1	62-1253-005	FUSE, 5mm X 20mm, TIME DELAY, 0.5A
	62-2982-001	FUSE RATING LABEL
A3T1	62-4476-001	TRANSFORMER
	61-4477-002	NAMEPLATE
	61-4478-001	POWER CORD ASSEMBLY

Section 4.10 Storage

The *A.T.S.* 1500 Tourniquet System has an operating temperature range between 10 and 38 degrees centigrade or 50 to 100 degrees fahrenheit.

The following are environmental conditions for transportation and storage:

A. Ambient temperature range	-17°C to 65°C
B. Relative humidity range	10% to 80%
C. Atmosphere pressure range	500 hPA to 1060 hPA

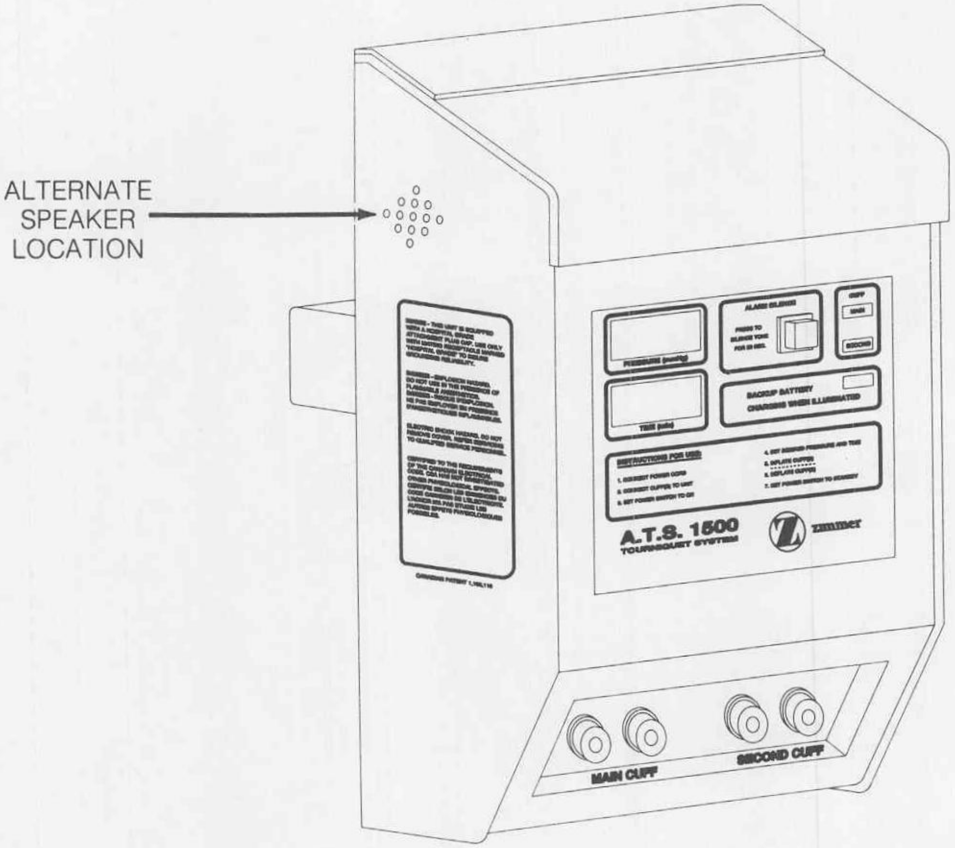
It is recommended that after the unit has been stored for a period of time, the unit should be plugged in and the batteries charged 24 hours prior to use.

Section 4.11 Supplied Equipment

Description	Part #	Quantity
A.T.S. 1500 Unit	60-4000-001-00	1
A.T.S. 1500 Manual	60-4019-002-00	2
A.T.S. 1500 Calibration Kit	60-1468-003-00	1
Tourniquet Stand with Base	60-4022-001-00	1
Dual Port, Dual Bladder Cylindrical Arm Cuff	60-7400-010-00	1
Dual Port, Dual Bladder Contour Arm Cuff	60-7400-011-00	1
Dual Port, Dual Bladder Large Contour Thigh Cuff	60-7500-008-00	1
Set Low Pressure Cuffs DPSB:	60-7400-005-00	1
Dual Port, Single Bladder Cylindrical Arm Cuff	60-7400-001-00	1
Dual Port, Single Bladder Contour Arm Cuff	60-7400-002-00	1
Dual Port, Single Bladder Contour Thigh Cuff	60-7400-003-00	1
Dual Port, Single Bladder Lower Leg Cuff	60-7400-004-00	1
A.T.S. 1500 Dual Hose, Blue/White	60-4017-001-00	1
A.T.S. 1500 Dual Hose, Red/White	60-4018-001-00	1
220V Transformer	62-4476-001-00	1
220V Power Cord	61-4478-001-00	1
220V Instruction Sheet	62-0801-001-00	1
Serial Number Tag	06-0011-044-20	1

Section 4.12 Alternate Speaker Location

The following diagram and parts apply to all *A.T.S.*1500 Tourniquet Systems and may replace the equivalent diagram and parts listed elsewhere in this manual.


ALTERNATE SPEAKER LOCATION
A.T.S. 1500
TOURNIQUET SYSTEM
zimmer
MAIN CUFF
SECOND CUFF

Parts unique to *A.T.S.*1500 alternate speaker location

Reference Designator	Zimmer Part No.	Description
P4B	62-1389-001	2 PIN CONNECTOR
P4A	62-1389-011	12 PIN CONNECTOR
		WIRE, 24 AWG, STRANDED, WHT/BLK (26.5 inches)
		WIRE, 24 AWG, STRANDED, WHT/ORG (26.5 inches)